Revisiting Bosumpra: Examining 10,000 years of plant use at the Bosumpra rockshelter, Ghana

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Abstract

In recent years there has been a growing interest in understanding the nature of prehistoric occupations and subsistence practices in the tropical forest regions of sub-Sahelian West Africa. These regions have long been considered as promising areas for investigating the antiquity and origins of oil palm (*Elaeis guineensis*) use and cultivation, a resource of immense economic importance today. This thesis examines Later Stone Age (LSA) subsistence practices and explores the interrelationships between LSA populations and plant resources in the tropical forests of Ghana during the Holocene. Using archaeobotanical evidence, I provide a long-term view of plant use at the Bosumpra rockshelter in southern Ghana over the course of the 10,000 years occupation, and I present the first detailed archaeobotanical analysis for pre-Kintampo LSA populations in Ghana.

This research documents the use and perhaps early management relationships with the oleaginous , incense tree (*Canarium schweinfurthii L.*) and oil palm, which are the most abundant food remains for all phases of occupation at Bosumpra. The collection and processing of these taxa, especially incense tree, were important activities performed at the shelter, and likely influenced the timing of the use of the shelter. The results of this study show the gradual displacement of incense tree by oil palm as the dominant tree-fruit resource at Bosumpra, and demonstrate the longstanding importance of both tree-fruit resources at the shelter well past the advent of food-production in Ghana. Remains of pearl millet and cowpea at Bosumpra document the appearance of plant domesticates in these forested habitats.

Although this analysis of plant materials from Bosumpra provides data from only a single site, the findings resonate with more widespread work on LSA subsistence practices, especially in regard to the importance of incense tree and oil palm to forest inhabitants. It also provides archaeobotanical evidence supporting previous models of the introduction and spread of West African plant domesticates. Altogether, archaeobotanical data from Bosumpra provide insights into changing practices of plant use and management during the LSA, and a subtle indication of what may be the earliest evidence of interaction and exchange between hunter-gatherers and food producers in this forest region.

Keywords: archaeobotany, Late Stone Age, Ghana, oil palm, incense tree, arboriculture, pearl millet, cowpea, subsistence, domestication.

Dedication

This thesis is dedicated to my parents, Peter and Barbara Oas.

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This thesis owes its completion to many individuals, more than I have the space here to thank, who have all been tremendous sources of support, inspiration, guidance, and encouragement. Pivotal throughout the course of this study and throughout my entire graduate career at Simon Fraser University, I first wish to express my gratitude to Professor Catherine D'Andrea whose guidance, encouragement, insightful feedback, and conversations about all things archaeological and archaeobotanical have been so important.

I thank Dr. Sarah Walshaw (Simon Fraser University) for many excellent and thought provoking discussions as well as for all her advice which she always gave so generously in the archaeobotanical laboratory. I wish to express my gratitude to Dr. Derek Watson (University of Ghana) for allowing me to work with the materials from Bosumpra, for all his hospitality during my stay in Ghana, and for sharing his archaeological knowledge and insights of LSA Ghana with me. Finally, I also wish to thank Professor Susan McIntosh for sharing her thoughts and perspectives about this research and about future directions it could take.

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1. INTRODUCTION

1.1 Investigating Later Stone Age forest occupations in Sub-Sahelian West Africa

In recent years, there has been a growing interest in understanding the nature and history of prehistoric occupations and subsistence practices in tropical forest regions of West Africa. While there is a growing body of evidence signaling immense socio-political, climatic, and environmental change taking place in these regions throughout the Holocene, there has been only limited archaeological investigation of Later Stone Age (LSA) occupations in these habitats. The LSA denotes a broad period in African prehistory spanning the early Holocene until the introduction of iron metallurgy and the practice of sedentary agriculture. It is broadly characterized by microlithic technology, ceramics, and mobile hunter-gathering subsistence strategies, although direct evidence for subsistence practices and plant use is unavailable in many regions (Casey 2005; Stahl 1993). However, archaeological investigations of the terminal LSA Kintampo tradition in Ghana have documented increasing sedentism, the presence of domesticated animals, and low-level plant food production (D’Andrea et al. 2001, 2006, 2007; D’Andrea and Casey 2002), which has led some scholars to question the usefulness of previous characterizations in adequately capturing the complex relationships and the range of subsistence practices and landscape usage which now appear to somewhat precede iron age occupations (Logan and D’Andrea 2012).

In sub-Sahelian West Africa, forest areas are thought to have been thinly occupied by highly mobile groups of hunter-gathers during the LSA, however investigations and evidence concerning the antiquity of these occupations, the nature of their social organization, interactions, and subsistence practices have been limited (Casey 2003). In part, these difficulties relate to the apparently ephemeral nature of LSA sites in forested environments, however there has also been limited sampling, analysis, or quantification of organic materials at these sites. Despite the scanty nature of the direct evidence for plant use, some broadly shared subsistence practices, including the widespread use, importance, and possibly management of oleaginous tree-fruits have been suggested from studies of several forested LSA sites dating to the early-mid Holocene (Lavachery 2001; Mercader 2003; Smith 1975). It is possible that the broad geographic extant of such subsistence practices indicates a greater level of interaction, communication, and perhaps resource management than previously thought by LSA populations in these forested environments prior to the advent of more sedentary food-production.

In Ghana, forest regions have long been considered important areas for investigating the antiquity and origins of oil palm (*Elaeis guineensis*) use and cultivation, a resource which is of immense economic importance in sub-Sahelian West Africa today. Particularly in the case of oil palm, Ghanaian rainforests are thought to be promising places to find early evidence for oil palm use and cultivation (Andah 1993; Clark 1976; Harlan et al. 1976; Harris 1976; Stahl 1985a, 1985b), and recent studies of Kintampo subsistence practices indicate oil palm production and possibly arboriculture were practiced in central Ghana by *c*. 3200 uncal. BP (D'Andrea et al. 2006; Logan and D'Andrea 2012). It is likely that in earlier periods human activities in the forests, related to the collection and consumption of this resource, would have played an important role in encouraging the growth and spread of this tree because it has high light and water requirements and yet it is known to have been widely distributed in closed forest environments throughout the Holocene (Hall et al., 1978; Hall and Swaine 1976, Mercader 2003).

1.2 Research Aims

In Ghana the collection and analysis of archaeobotanical remains, although more commonly practiced here than in many regions in Africa, is limited in the southern rainforest regions. In part, this is a product of poor site visibility, which has impeded survey and excavation attempts. However, historically there has also been little systematic sampling or quantitative analysis of botanical remains at LSA sites, which are important sources of data for understanding the relationships between peoples and plant resources in the past. In order to address this oversight, the aim of this thesis is to provide insight into LSA forest occupations and subsistence practices by examining continuity and change in plant use over time through the systematic analysis of seeds, nutshell, and wood charcoal remains from the Bosumpra rockshelter.

As a rockshelter, Bosumpra is an appealing choice for investigation, not only because of the potential for good preservation of archaeobotanical materials, but also because shelters are promising locations to investigate mobility strategies, site function and activity areas, and local resource utilization and management (Casey 2005; Marshall and Hildebrand 2002; Walthall 1998). Unlike open air sites, where hunter-gatherers usually leave only ephemeral traces, rock shelters are fixed locations both in terms of habitable size and their placement on the landscape (i.e., facing direction, proximity to water and other resources), and as such they are often repeatedly occupied, allowing for the accumulation of rich archaeological deposits. As temporary habitations rockshelters are also of particular interest in palaeoethnobotanical studies because the charred plant materials recovered most likely reflect the selection of local plant resources for fuel, food, or other uses. When investigating the management of plants, even a slight change in local habitats could enhance the growing environments for certain taxa without radically altering established subsistence routines (Marshall and Hildebrand 2002; Brosius 1991).

In tracking changes in hunter-gatherer subsistence practices over the Holocene, a particular focus of this research involves an examination of how the use of oil palm and other oleaginous tree-fruits in these forest environments change over time at the shelter. Providing the first full analysis of macrobotanical remains at Bosumpra, I assess previous, though untested, observations about changes tree fruit use at the shelter (Smith 1975). As a remarkable occupation sequence of over 10,000 years has recently been established at Bosumpra (Watson in preparation), I use this unique diachronic sequence to document, compare, and contrast archaeobotanical data from this shelter with data available from other Later Stone Age forest sites. I situate the results of this study in broader discussions of hunter-gatherer subsistence adaptations and strategies in these habitats, and I begin to explore how relationships with plant resources may have changed with the advent of food production and the appearance of domesticated plants in central-southern Ghana. As understanding changes in the local forest vegetation and the environment surrounding Bosumpra are important in understanding the nature of plant use and subsistence practices at Bosumpra, a small wood charcoal study was also undertaken as part of this research to provide some preliminary data about local climatic and vegetational conditions over the Holocene (See section 4.3 of chapter 4).

1.3 Overview of Thesis

Chapter 2 of this thesis provides an introduction to the modern landscape, climate, and vegetation of Ghana, as well as a review of the palaeoclimatic and palaeoenvironmental data available for the region. This is followed by a more detailed discussion of the characteristic tropical forest types and several important wild and domesticated plant resources known from Bosumpra, as well as other studies of LSA subsistence in Ghana. The chapter concludes with a brief overview of LSA archaeological work in Ghana, focusing the site of Bosumpra itself, providing a brief overview of previous archaeological work and the most recent excavations. Chapter 3 provides a brief description and discussion of the methods employed in the field and laboratory for this study of charred plant remains recovered from Bosumpra. In Chapter 4, the results of the analysis of macrobotanical materials are presented, with a discussion of the major patterns in the macrobotanical data presented in Chapter 5. The final chapter, Chapter 6 summarizes the major conclusions of this research.

2. GHANA PAST AND PRESENT: PUTTING BOSUMPRA IN CONTEXT

2.1 Introduction

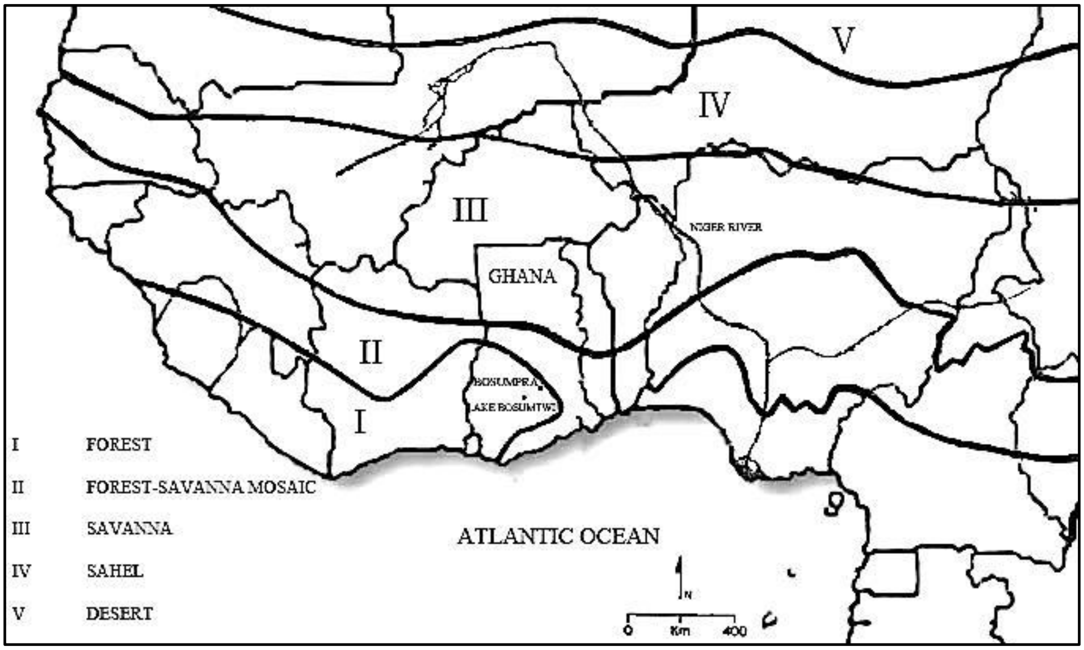
In this chapter, I provide an introduction to the region, discuss several key plant taxa of modern and ancient importance in Ghana, and present an overview of Later Stone Age (LSA) archaeological research. I begin by providing a general introduction to the physical terrain, ecological zones and climate of Ghana, and a brief discussion of the palaeoenvironmental record for the region in which Bosumpra lies. This is followed by a more detailed description of the tropical forest vegetation, the biology and uses of several key food and medicinal plant species, with a focus on taxa for which there is direct macrobotanical evidence from the LSA. I then present an overview of the LSA archaeological work completed in Ghana, and discuss the most recent archaeological evidence and interpretations of LSA subsistence practices. Finally, I conclude with a summary the archaeological work at Bosumpra, highlighting the results from the most recent excavation.

2.2 Physical Terrain, Climate, and Palaeoenvironment

The terrain in Ghana, like much of West Africa, consists of low-lying plains and plateaus, with major vegetation zones forming several roughly latitudinal bands. Today, West Africa is typically divided into five east-west running vegetation zones (Figure 2.1) according to the amount of precipitation (i.e., total amount and annual distribution) and physiognomic characteristics of the vegetation (White 1983). In general, the amount of precipitation for each zone decreases as one moves north.

Today, the national border of Ghana encompasses three of these zones (Figure 2.1). The northern half of the country is characterized by park-like savannah environments and grassy plains, with central Ghana covered by a relatively narrow band of transitional dry-forest (Keay 1959). The southern third of the county, the region in which the Bosumpra rock shelter is located, is covered in deciduous and semi-deciduous wet-forests (Keay 1959; Lawson 1986; White 1983).

Figure 2.1 Vegetational Zones of Western Africa (modified from White 1983)

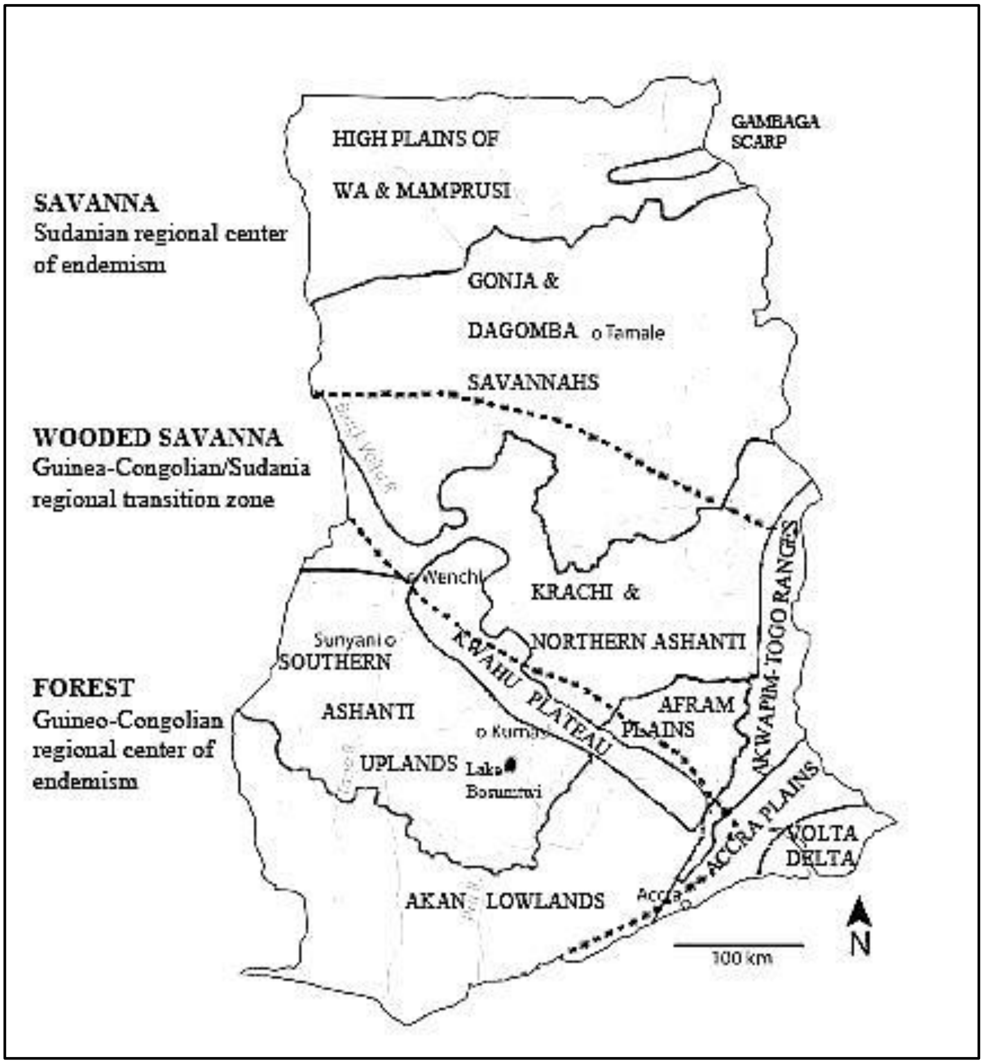


2.2.1 The Ashanti Uplands

The Bosumpra rock shelter is one of a series of sandstone caves and shelters situated on the eastern slopes of the Kwahu Plateau, which form the easternmost part of the Ashanti Uplands. The uplands lie just north of the Akan Lowlands, running from the western border of Côte d'Ivoire to the edge of the Volta Basin. The Kwahu Plateau stretches diagonally across central-southern Ghana some 193 km from the northwest to the southeast (Figure 2.2).

While the terrain of Ghana is mostly comprised of low-lying plains, the Kwahu Plateau creates an important physical division between southern and northern-central Ghana, and marks the modern northernmost extent of the forested region (Figure 2.2). The Kwahu Plateau is also the main watershed in Ghana, separating the rivers that flow into the sea from those flowing into the Volta. The headwaters of the Afram and Pru are found in the northeast, where several smaller seasonal rivers also flow down from the Kwahu plateau to join with the Volta. In the southwest the Pra, Birim, Tano and other rivers emerge and flow down into the sea (Boateng 1970).

Figure 2.2 Geographical Regions of Ghana (modified from Boateng 1970:145)



The average elevation of the Kwahu Plateau is 450 m asl with a maximum elevation of 762 m asl (Boateng 1970: 170). At an elevation of 613 m asl, Bosumpra lies north-east of the modern village of Abetifi, the highest modern habitation in Ghana at around 640 m asl (Watson in preparation). At the elevation of Bosumpra, there is a higher amount of precipitation and lower temperature than the surrounding lower-lying areas (Hall and Swaine 1976).

Other important natural features in the vicinity include the largest natural lake in Ghana, Lake Bosumtwi (ca. 6°N 1°W), (Fig 2.1) a roughly 21 km² crater lake approximately 70 km southeast from Bosumpra. As Lake Bosumtwi is purely rain-fed, studies of lake sediment cores have been used to reconstruct regional palaeoenvironmental conditions over the last 20,000 years (Russell 2003; Shanahan et al., 2006, 2008, 2009, Talbot et al. 1984).

2.3 Climate: Precipitation and Seasonality

The vegetation zones of Ghana are mainly determined by climatic conditions, (i.e., temperature, precipitation, and seasonality). Climatic conditions are largely based upon the northward and southward movements of two principle air masses. The monsoon brings cool, moist air from the southern Atlantic, and the Saharan *harmattan* wind brings hot, dry air from the northeast. As the air masses meet and converge from opposite sides of the equator they form a belt of ascending air known as the Inter-Tropical Convergence Zone (ITCZ). The somewhat irregular movements of the ITCZ, as it oscillates slowly from north to south, are a main determining factor for the region's tropical weather and precipitation. The ITCZ reaches its furthest northern extension in August, and its furthest southern position in January, which determines the timing of wet and dry seasons in Ghana (Nicholson 2009; Wills 1962: 7-10). It is clear from palaeoenvironmental studies, that the position of the ITCZ has been prone to frequent and occasionally dramatic shifts, meaning that the boundary between the forest and savanna zones has at times shifted further north or south than at present (Shanahan et al. 2009).

Temperatures in Ghana remain high throughout the year with only small variations in the annual mean temperature across the country. However the lowest temperatures generally occur near the coast and highest in the northernmost regions (Boateng 1970). The average maximum temperatures occur throughout almost all of Ghana in March, and the lowest average temperatures in January (Wills 1962: 16-17). In the forest regions mean temperatures in the wet season are 25ºC and in the dry season 27 ºC (Hall and Swaine 1976: 919). In addition to the effects of the ITCZ, temperatures in Ghana are also related to local topography, with about a 1°C drop in temperature for every 100 m in elevation (Hall and Swaine 1976: 919).

Seasonality and precipitation patterns, especially the timing, duration, and intensity of rainfall, have important implications for the distribution of vegetation and agricultural practices in Ghana, and are the main factors in determining when and what types of crops can be grown. Rainfall in Ghana, even over relatively short distances, is largely determined by the movements of the ITCZ, and generally rainfall is highly variable in both the total annual amount and the timing of distribution. The south-west regions receive heaviest rainfall, generally exceeding 1750 mm per year, although similar amounts also fall in hilly regions of the Ashanti Uplands and any other areas above 600 meters (Hall and Swaine 1976: 918; White 1983: 72). Farther north, the savanna woodland region of central Ghana receives 1000-1500 mm annually, and in the extreme northeast less than 1000 mm of rainfall occurs annually (Hopkins 1974: 8-10).

Even the wettest regions of Ghana have at least two seasons, a wet and a dry season, with the dry season generally lasting four or five months during which less than 100 mm of rain falls (White 1983). The southern forests of Ghana experience two yearly peaks in rainfall, a major one in May-June and subsidiary one in September-October. Further inland, northern Ghana experiences only one brief wet season August-September that is followed swiftly by a long dry season (Wills 1962).

2.3.1 Current Palaeoenvironmental Reconstructions

Increasingly fine-scale reconstructions of Late Pleistocene and Holocene climatic conditions are available from studies of terrestrial lake sediments, and marine cores for northern Africa (i.e., Damnati 2000; Duport et al., 2000; Brooks 1998). These show broadly similar patterns of climate change over this period a picture as well as regional variations in temperature, rainfall patterns, and the distribution of vegetation. In general, the major changes in temperatures and precipitation patterns appear to be largely correlated to northern hemisphere glacial activity and changes in the movements of the ITCZ (Shanahan et al. 2006).

In Ghana, the timing of these major climatic events appears to be similar to the rest of tropical northern Africa, particularly for the Early Holocene. The boundaries of forest and savanna vegetation zones in Ghana have changed considerably over time in response to climatic change, particularly in terms of precipitation, moving northward, in wetter, or southward in drier phases (Brooks 1998). Climatic change in the mid- to Late Holocene however, seems to be less synchronized with lake-level variations in other areas of Africa. Thus in these later periods, regional local topographic, hydrological, and anthropogenic influences, likely became more important factors that determined lake levels and local environmental conditions (Russell 2003; Shanahan et al. 2006; 2008).

While late Pleistocene and early Holocene paleoecological data are limited, the main source of palaeoenvironmental data for central Ghana comes from studies of the sediment cores of Lake Bosumtwi (Talbot et al. 1984; Russell et al. 2003; Shanahan et al. 2006, 2008, 2009). High resolution reconstructions of annual precipitation from Lake Bosumtwi have allowed for a detailed picture of environmental change over the last 20,000 years. The following sections will discuss briefly the major climatic phases estimated for this period in sub-tropical northern Africa and the conditions in central Ghana as indicated by studies at Lake Bosumtwi.

2.3.1.1 Late Pleistocene-Early Holocene (20,000-5,000 cal. BP)

Palaeoenvironmental data for the savanna and forest regions of Ghana are limited for the Pleistocene and Early Holocene, and many questions remain unanswered particularly concerning the extent of tropical forest habitats in West and Central Africa. Models proposed by some scholars suggest that tropical forests during the Late Pleistocene would have been highly reduced and fragmented, with only small regions of forest “refugia” persisting amidst more dry forest and savanna vegetation (Duport 2000:112; Maley 1987, 1989; Talbot et al. 1984). In recent years however, others have argued that palaeoenvironmental data indicate the persistence of a more substantial tropical forest even in the cooler, drier periods of the last Glacial Maximum (for a detailed discussion see Mercader 2003: 4-11). Overall, palaeoenvironmental data do indicate that conditions in the mid- to Late Pleistocene were cooler and drier than today. Palynological data, in particular indicates a much higher percentage of montane species, suggesting that in mid to Late Pleistocene temperatures were lower, perhaps by even as much as 3-4° C. In addition the amount of precipitation could have been as much as 25% lower than at present (Maley 1993:48).

Palaeoecological data from Lake Bosumtwi *c*. 20,000-15,000 cal. BP, suggest that there was a great reduction in forest habitats during this last major arid phase of the Quaternary (Maley 1987, 1989). Lake levels began to rise at Bosumtwi *c*. 16,300 BP-14, 500 cal. BP, and continued to increase until 14,300 cal. BP (Shanahan et al. 2006). By *c*.13,000-12,000 cal. BP the first signs of reforestation occur, although at *c*. 12,600 -11, 600 cal. BP Bosumtwi lake levels dropped significantly, an event likely reflecting the effects of the Younger Dryas stadial (Shanahan et al. 2006). Lake levels returned to former high levels by 11,000 cal. BP, when Lake Bosumtwi achieved its deepest state, overflowing its crater. This fits into the broader regional palaeoenvironmental reconstructions from other terrestrial and marine pollen cores which indicate that in the Early Holocene *c*. 10,000 cal. BP the extent of the rainforest was greater than present (Duport 2000: 112). By *c*. 9000 cal. BP, in a period of increased precipitation and with a longer wet season, the region around Lake Bosumtwi was fully forested once again (Maley 1987, 1989; Talbot et al. 1984). This overflow period lasted until *c*. 8,800 cal. BP, when a short but significant drop in lake level occurred (Shanahan et al. 2006, 2008).

2.3.1.2 Mid- Late Holocene (5,000 cal. BP to present)

Conditions elsewhere in tropical northern Africa became increasingly arid after 6000 cal. BP and ultimately began to resemble modern climatic conditions 5000-4000 years ago (Damnati 2000). Further south in sub-Sahelian Benin, palaeoenvironmental data from the sediment core of Lac Sélé indicate the rapid onset of arid conditions in the region 4500-3400 cal. BP, coinciding with the rapid reduction of rainforest vegetation and the formation of the Dahomey Gap (Maley 1991,1993,1996; Maley and Chepstow-Lusty 2001). Analyses of the sediment cores at Bosumtwi show deep, though not overflowing, lake levels were re-established *c.* 7,200 cal. BP, which remained high until *c*. 3,200 cal. BP when the lake level dropped severely to resemble modern levels (Russell et al. 2003:7).

The timing of the termination of the sapropel (indicating the African or Holocene humid period) appears later in southern West Africa, and it is later in central Ghana than in Benin likely due to variations in the ITCZ and local differences in soil and vegetation (Shanahan et al. 2006: 299). However the regression of lake levels and increase in the pollen amounts of Guineo-Savanna species at Bosumtwi are likely related to the major climatic changes recorded from Lac Sélé (Salzmann and Hoelzmann 2005: 197). The arid period indicated for Lake Bosumtwi beginning 3,200-3000 cal. BP was part of a broad climatic shift towards modern conditions with a more pronounced seasonality and a longer dry season (Russell 2003; Shanahan et al. 2006; Talbot et al. 1984). Following this arid phase, a return to slightly more humid conditions followed at Lake Bosumtwi, with late Holocene lake highstands at 2,200 and 1,700 cal. BP (Shanahan et al. 2006.)

In summary, conditions between 20,000 and 15,000 BP were cooler and more arid, and the extent of the forest was reduced. By 13,000-12,000 BP this began to change, and after a cool, dry interval likely related to the Younger Dryas *c*. 12,500-11,500, wetter than today climate conditions with peak lake levels were present by 10,000-9,000 BP. These conditions were present again in the Middle Holocene, appearing after another brief cooling event *c*. BP 8200-8100 cal. BP, and lasted until modern climatic conditions were established at Lake Bosumtwi around 3,200 BP.

2.4 Vegetation: Forests and Fields

2.4.1 Guineo-Congolian Rainforest

The lowland rainforest vegetation surrounding the Kwahu Plateau today has been heavily modified by logging and shifting agricultural practices. These activities have displaced much of the old growth forest in southern Ghana, resulting in large regions of secondary regrowth forest and an abundance of fast growing pioneering taxa, especially along footpaths, surrounding villages, and in fallow fields or abandoned farms (Keay 1959: 7; White 1983: 75). The remaining relict stands of mature forest consist of taxa characteristic of White's (1983: 71-85) Guineo-Congolian regional centre of endemism, Keay's (1959: 7) Moist Forest at Low and Medium Altitudes, or the Ghanaian Dry Semi-Deciduous forest type described by Hall and Swaine (1976).

The numerous variations of rainforest recognized in Ghana are a result of the wide range and uneven distribution of rainfall in addition to local differences in elevation. White (1983: 76-80) described his main variants of Guineo-Congolian rainforest, based on annual rainfall, humidity, and the endemic flora. These are coastal evergreen; mixed moist semi-evergreen; single dominant moist evergreen; and the semi-evergreen rain forest; and, drier peripheral semi-evergreen rainforest. The mixed moist semi-evergreen type, with a mean annual rainfall between 1600-2000 mm was historically the most common type of forest found in southern Ghana (White 1983: 76). Studies of the pollen as well as of fossil leaf impressions from shoreline sediments of Lake Bosumtwi suggest that the same moist semi-deciduous and dry semi-deciduous forest types growing around the lake today were also present in the Early Holocene between *c*. 10, 000 and 9880 uncal. BP (Hall et al. 1978: 249).

The remaining regions of mature Guineo-Congolian forest are characteristically composed of evergreen or partially evergreen trees. While a few of these species are occasionally deciduous, the forest is almost never totally leafless. When compared with other tropical rainforests, the Guineo-Congolian forest generally receives less, and more unevenly distributed rainfall throughout the year, growing under a range of 1200-1750 mm (Hall et al. 1978: 258). In addition, while the flora of the Guineo-Congolian rainforest is one of the most diverse in Africa, it is relatively less rich than tropical rainforests on other continents (White 1983: 74).

Today, the region of the Kwahu Plateau where Bosumpra lies has a relatively cool and wet climate (Figure 2.3), and because of its higher elevation this region is characterized by a sub-montane vegetation making it distinct from the lower surrounding forests (Hall and Swaine 1974). This region of upland forest is generally less deciduous than the lowland forest, and it has a unique mixture of wet evergreen and semi-deciduous forest species along with rare epiphyte and montane species. The vegetation of the Guineo-Congolian forest is generally at least 30 m tall, though it often is much taller (i.e., 55-60 m high), however these upland forests frequently have a lower canopy height (Hall and Swaine 1974).

Figure 2.3 Kwahu Plateau (photo by author)

Most of the rainforest species in Guinea-Congolian forest are woody, with 31 percent of the taxa in Ghana represented by woody climbers (Figure 2.4). In the wetter upland regions on the Kwahu Plateau, epiphytic herbs (i.e., orchids and ferns) are more abundantly represented because regions with higher elevations have lower temperatures, are mistier, and have higher precipitation (Hall and Swaine 1974; Swaine and Hall 1986: 65). While terrestrial herbs (i.e., broad-leaved grasses and sedges), are now well represented in regions of the forests near paths and farmlands, they are rarely found in undisturbed forest vegetation (White 1983: 75).

Figure 2.4 Guineo-Congolian forest surrounding Bosumpra (photo by author)

In general the amount and intensity of rainfall is a key factor in determining the floristic diversity of tropical forests. In West Africa, higher precipitation leaches the soil, increases acidity and reduces soil fertility (Swain and Hall 1986: 63-64). However the unique species composition found in surveys of upland regions also demonstrates the importance of altitude (in terms of temperature, precipitation, humidity etc.) on the floral composition of the forest. Further local variation in the local patterns of rainforest species distribution is largely determined by the light environment (i.e., the temporal and spatial availability of light in the lower canopy) which can be modified through both natural and human actions (Swaine and Hall 1986: 58)

2.4.2. Useful Plants: Important Food Resources dating to the LSA

Today the crops and staple foods of Ghana present a complex mosaic reflecting not only different agricultural regions and vegetation zones of the country, but also the long history of regional and global exchange and interaction between different areas of Africa, the Near East, and the Americas (Logan 2012). The use and cultivation of many of these important plants likely began during the LSA in West Africa, though understanding of the origins and the role of these plants in LSA diets of these plants remains limited.

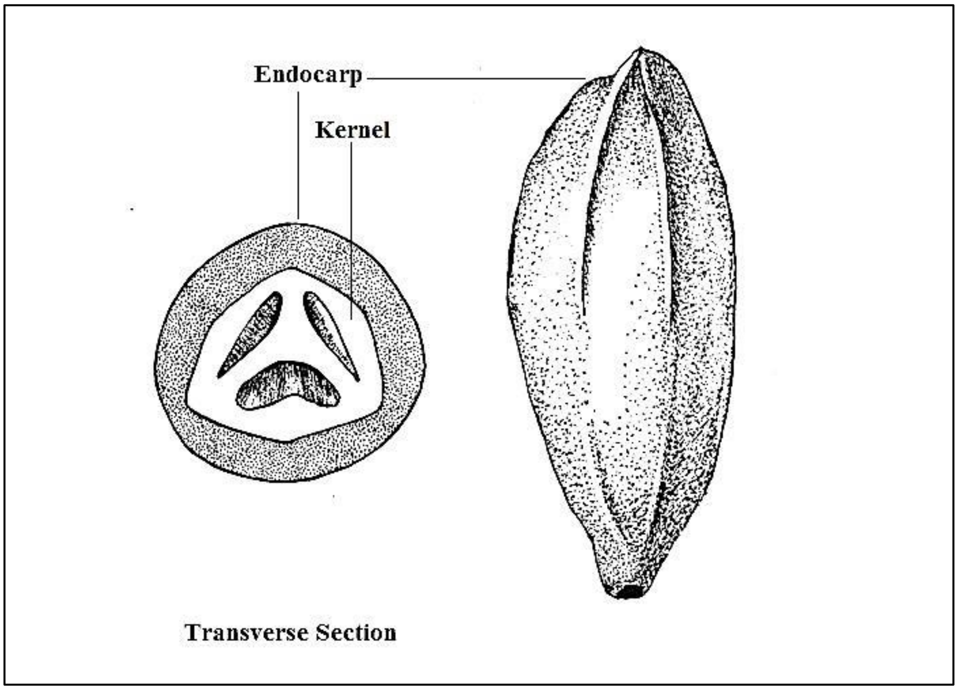
It is important to mention that it has long been thought that there has been a deep history of yam (*Discorea* spp.) and oil palmcultivation in the rain forest habitats of West Africa (Andah 1993:246-248; Stahl 1993: 264). Not only do both species have fairly high water requirements, but they also require human aid to thrive inside the closed canopy of the forest (Alexander and Coursey 1969; Harris 1976: 334, 338; Posnansky 1984: 150). While remains of oil palm are often found in LSA archaeological contexts, unfortunately no direct archaeobotanical evidence is available for the presence of yams. As tubers are rarely preserved in archaeological contexts, and the recovery of starch remains has thus far been unsuccessful in West Africa, evidence for the time depth of yam usage remains limited to indirect biological (Coursey 1972, 1976), ethnoarchaeological (Ichikawa 1992; Okigbo 1980), and historical linguistic evidence (Blench 2007; Williamson 1993). Therefore, although it is likely that yams (wild and domesticated) were an important part of the diet of hunter-gatherer groups in rain forests of Ghana, they will not be discussed in further detail in this thesis.

The following sections will instead focus on several of the important plant species for which there is the best direct archaeological evidence for in the LSA in Ghana. These include incense tree and oil palm, trees that produce oily fruits which were likely essential sources of dietary starch and fat for LSA populations in tropical forest habitats. Domesticated plants will also be discussed, including pearl millet (*Pennisetum glaucum*) which was introduced to Ghana from the northern Sahelian regions in its domesticated form, and cowpea (*Vigna unguiculata*) that was likely domesticated locally in during the LSA.

2.4.2.1 Incense Tree

Canarium schweinfurthii (L.), incense tree or the African black olive, is a deciduous tree belonging to the large genus *Canarium* in the Burseraceae family. The center of *Canarium* diversity and likely origin is in Southeast Asia and the Pacific Islands. However, *Canarium schweinfurthii* is the primary species distributed throughout tropical Africa, where it has long been isolated from other species of the genus (Leenhouts 1959: 385). Incense trees grow up to 50m high and up to about 2m in diameter. The tree produces fruits between October and March, during the wet season, which means that the presence of incense tree fruit remains in archaeological contexts are a potential marker of seasonality (Flight 1976: 216; Stahl 1985b: 226). Incense tree fruits are ovate drupes around 3-4cm in length and 1.5-2cm in diameter, consisting of a skin (epicarp) surrounding a fleshy, oily mesocarp, and a stony interior drupe (endocarp) surrounding the seed or kernel (Leenhouts 1959:384) (Figure 2.5).

Figure 2.5 Canarium schweinfurthii fruit (modified from Fauna and Flora of Liberia 2013)



Today incense tree is widely distributed throughout tropical Africa in rain forests, gallery forests and transitional forests in regions with elevations up to 1300 m asl, and with mean annual rainfall between 900-2,200 mm (Leenhouts 1959:382). While incense tree is more shade tolerant than oil palm, it is still considered a secondary forest tree, and is unable to regenerate in the full shade of the primary forest canopy. This means that incense tree is most often found in in riverine regions, areas of secondary forest growth, or in human made clearings. Recent surveys of forest in Ghana found that while widely dispersed, incense tree does not appear with high frequency anywhere even in modern disturbed secondary forests (Hall et al. 1978: 259; Hall and Swaine 1976).

Unlike oil palm, incense tree has never been cultivated and today it is not considered to be economically important except in a few areas. However, incense tree fruits (endocarp), contain a fleshy mesocarp that produces high quality oil (30-50% fat) (Georges et al. 1992; Irvine 1961: 509). The oil quality is similar to olive and palm oils (Abayeh et al. 1999), with a high total oil content consisting of oleic and linoleic acids (Davidson and Nkeh 2003). Both the seeds and the fleshy pulp are eaten after boiling in some regions, and edible oil can be extracted and used as cooking oil (Abeyeh et al. 1999; Leenhouts 1959: 385).

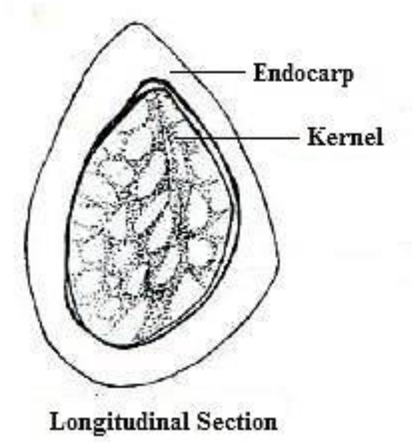
Incense tree fruits have long been a part of the diet of hunter-gatherer populations living in the rainforests of central Africa (Ichikawa 1992; Mercader 2003). In addition, the bark, seeds, and other parts of the tree are used in traditional medicine as stimulants and moisturizers, and to treat illnesses such as fever and rheumatism (Hutchinson and Dalziel 1954). Testing of stem bark extracts has demonstrated that incense tree has anti-diabetic properties (Kamtchouing 2006). Additional analysis of the essential oils in the resin of incense tree has shown significant analgesic (Koudou 2005), anti-inflammatory and antimicrobial effects (Obame et al. 2007). Incense tree resins are also collected and used as simple illuminants, caulking for canoes, and as a sealant for cracked pottery (Eggert 1993: 324; Irvine 1961: 508-510). Oil from the resins is also burned as an aromatic incense and to drive out mosquitoes (Eggert 1993:324; Leenhouts 1959: 385). The hard-coated seed and wood are used in handicrafts, often carved and used as decorations (Leenhouts 1959: 385).

2.4.2.2 Oil Palm

Oil palm (*Elias guineensis* Jacq.) of the family Arecaceae, is a wind pollinated heliophytic pioneer species indigenous to sub-Saharan Western and Central Africa. Today oil palm flourishes in the transition zones between the deciduous forest and savanna zones and in areas cleared for agriculture (Hartley 1967; Zeven 1967, 1972). A pioneer species, oil palm naturally thrives in forest fringe habitats and along the edges of rivers, and is unable to grow in the shady regions of the primary forest canopy. Oil palm requires at least 5-7 hours of sunlight daily, performing best in regions with high rainfall, above of 2000 mm annually, and low seasonality with a mean minimum temperatures between 22-32°C (Hartley 1967:94).

The most common variety of oil palm (*E. guineensis var. communis*) has five main fruit forms that vary in thickness and oil content (Hartley 1967: 37-40; Irvine 1961: 24-26). The fruit is a drupe, consisting of one or more kernels encased in hard shell (endocarp) that is surrounded by a soft oily fibrous layer (mesocarp) and a reddish outer skin (epicarp) (Hartley 1967: 37-40) (Figure 2.6). Oil palm trees produce fruit after three to four years, and after five years the bunches are large enough to collect. After eight to ten years a tree will produce two to twelve bunches annually, though as the tree ages the number of bunches decreases with an increase in the overall weight of the bunches (Irvine 1961: 26).

Figure 2.6 Elaeis Guineensis Fruit (modified from D'Andrea et al., 2006:199)



Oil palm is an integral part of the modern Ghanaian economy, as it is in tropical regions world-wide, where it is a major export and source of oil, food, drink, medicine, and construction material (Hartley 1967; Irvine 1969). While the fleshy mesocarp and kernels of oil palm fruits are occasionally consumed by themselves, these parts are primarily processed to create cooking oil. Today palm oil provides an important source of vitamin A in regions that fall within the tsetse fly belt, where the ability to keep livestock is limited by disease such as trypanosomiasis (sleeping-sickness). The consumption of palm oil provides an important source of dietary fat, balancing the regional starchy dietary staple root crops such as yam and cassava (Harris 1976: 338; Hudelson et al. 1999).

While oil palm fruits are most commonly used to produce cooking oil, various parts of the tree can be used for eating, drinking, construction, or medicinal purposes (Irvine 1961: 777). The sap of oil palm trees is used to make palm wine and other fermented beverages (Irvine 1969; Zeven 1972). A decoction made from oil palm roots used as a medicine to treat headaches, rheumatism, and intestinal pain (Irvine 1961; Burkhill 1997). The stems, fronds, and leaves are used as construction materials (Irvine 1961; Hartley 1967; Burkhill 1997), and the fibres have been used to create lines for fish-traps (Andah 1993: 248) and can be burned along with the shell or endocarp of the oil palm fruit as fuel (Burkhill 1997; Irvine 1969).

2.4.2.3 Pearl Millet

Pearl millet (*Pennisetum glaucum* (L.) R Br.) is one of the earliest known plant domesticates in Africa, and it has been recovered from West African sites dating to the fourth millennium BP (Manning et al. 2011; Marshall and Weissbrod 2011). In Ghana the earliest evidence for pearl millet comes from the northern Kintampo site of Birimi (D'Andrea et al. 2001), where it is thought that that the adoption of pearl millet cultivation was a local response by Kintampo populations to increasing aridity and more pronounced seasonal climates (D'Andrea and Casey 2002). Until very recent times pearl millet has remained an important dietary staple in sahel regions of northern Ghana, where it is especially well adapted to arid conditions and a prolonged dry season. Pearl millet is an important source of starch carbohydrate in these arid zones, as well as a source of protein and essential amino acids (Burkill 1994: 316). The grains are used in a variety of ways as food, ground into flour and eaten as porridge or as bread, and pearl millet is also brewed into beer. The green plant is also occasionally grown and used as fodder (Purseglove 1976: 91; Burkill 1994: 316).

Today, four landraces of pearl millet are recognized: typhoides, nigratarum, globosum, and leonis, which are slightly different maturation rates and water tolerances, and are distinguished largely by grain shape (Brunken 1977; Brunken et al. 1977). The diversity of modern grain shapes and sizes is due in large part to cross-pollination with wild and domesticated varieties of millet, and the effects of human selection and cultivation. In addition to these varieties of millet there are also weedy, hybrid forms of wild millets known as shibras, which closely resemble domesticated pearl millet and thrive alongside domesticated pearl millet in weeded fields (Brunken et al. 1977: 163; Burkill 1994: 315).

Current climate conditions prevent the large-scale cultivation of pearl millet in the southern tropical forest habitats of Ghana. Because pearl millet is adapted to arid environments, and requires a more marked dry season for the grain to ripen, too much rainfall or rain at the wrong times can lead to crop failure (Irvine 1969: 144; Purseglove 1976). In Ghana, as the mean annual rainfall approaches 1000 mm in the south, pearl millet cultivation tends to be replaced with sorghum, and it disappears almost entirely within the tropical forest zone (Brunken 1977: 170). It should be noted that recent finds of pearl millet in southern forested Cameroon at 2400-2200 cal. BP provides some surprising evidence for local pearl millet cultivation within a rainforest habitat (Kahlheber 2009; Höhn et al. 2008; Neumann et al. 2012). While palaeoenvironmental studies indicate that this region saw a marked decrease in humidity and the appearance of a distinct dry season, it is also possible that more water-tolerant landraces of pearl millet existed in the LSA that no longer are grown today.

2.4.2.4 Cowpea

Cowpea (*Vigna unguiculata* (L.) Walp.) is one of the most important leguminous crops grown in the savanna zones of West Africa and Central Africa. It is the second most important native legume, and it is second in importance overall in sub-Saharan Africa (National Research Council 2006: 105). Although cowpea has long since spread throughout Africa and beyond, the greatest genetic diversity can still be found in West Africa where it was likely first domesticated and where the earliest directly dated cowpea has been found (D'Andrea et al., 2006; Lambot 2002; Rachie and Roberts 1974: 44; Simmonds 1976; 183). Like pearl millet, cowpea is mainlya savanna species that thrives even with poor soil conditions and unpredictable seasonal growing conditions. As a result cowpea is a dependable food source in regions of northern and central Ghana, thriving where other crops do not perform as well (National Research Council 2006: 107). There are many varieties of cowpea with different flowering and ripening times, some of which are very short, allowing for farmers to grow at least one variety throughout the year (Irvine 1969: 200-203).

Cowpea for many sub-Saharan populations is a vital source of protein and essential amino acids. In West Africa, cowpea significantly improves the protein quality of a diet mainly composed of bulky staples (e.g., rice, maize, cassava) that are largely carbohydrate based (D'Andrea et al. 2007; National Research Council 2006: 105; Simmonds 1976: 183). It is often combined with vegetables and oil palm to produce a thick soup which is served with a starchy staple (e.g., yam, cassava), or it can be ground into flour and mixed with millet to make small fried cakes. In addition to eating the pods and seeds, the dried and fresh young leaves are frequently eaten boiled or fried throughout West Africa (National Research Council 2006: 108; Rachie and Roberts 1974: 61).

Other parts of the plant are recognized to have uses in medicine, as dyes, or as a source of fibre for textiles (Burkill 1995: 479;; Irvine 1969: 202). Additionally, the leaves and seeds are often used as fodder, growing back even after several cuttings, and it has been suggested that this was the reason behind its initial domestication (Burkill 1995: 479).Cowpea can be grown as a crop by itself, but it is frequently intercropped with the cereals sorghum and millet (Rachie and Roberts 1974: 45). Cowpea is also grown as ground cover that can help prevent soil erosion, and is used as green manure (Rachie and Roberts 1974: 45). In addition, as a legume it is also an important nitrogen fixer for the soil, increasing the productivity of other crops (National Research Council 2006: 109).

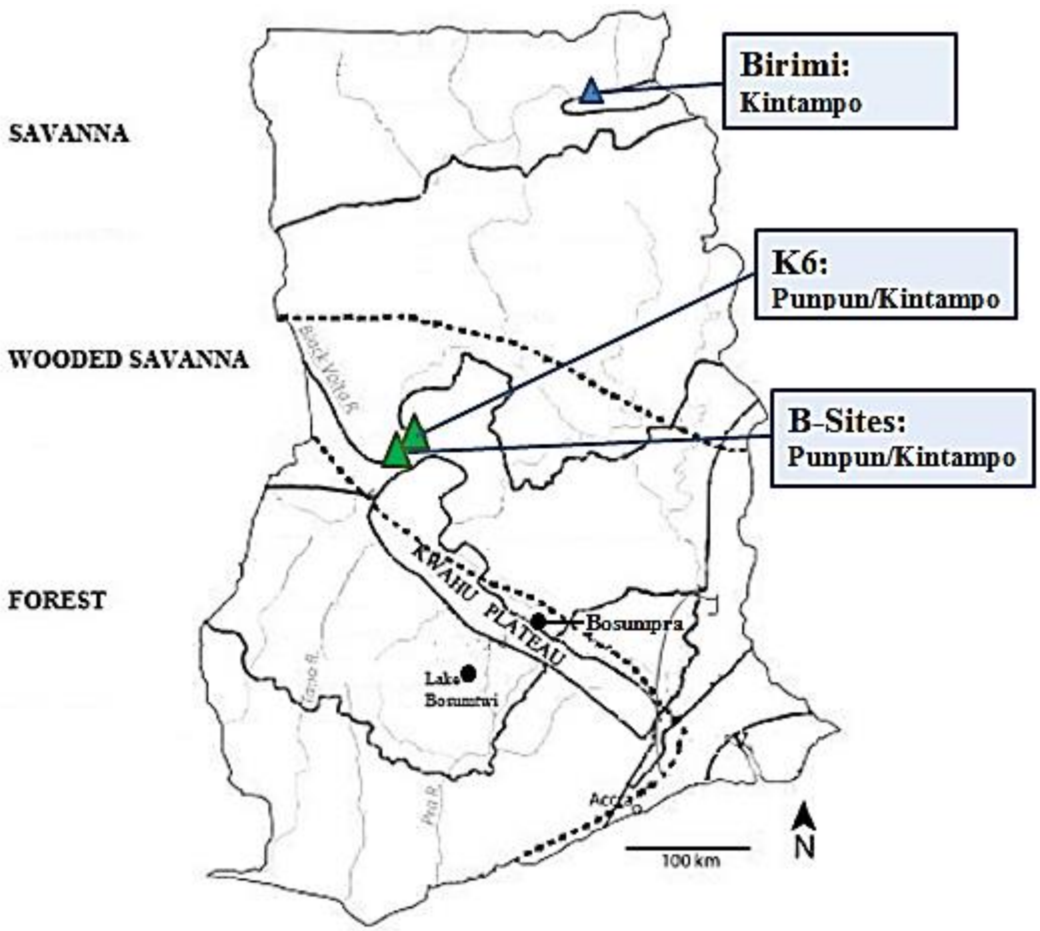
2.5 Later Stone Age Archaeology in Ghana

Archaeological evidence for the earliest use and cultivation of these taxa in Ghana comes from terminal LSA archaeological sites, and it is worth briefly examining what is currently understood about these populations and their subsistence practices. The most intensively studied LSA population is the Kintampo Tradition, which provides some of the best archaeological evidence for early food production and sedentism in sub-Sahelian West Africa (Anquandah 1993; Casey 2000; Davies 1962; Dombrowski 1980; Flight 1976; Posnansky 1984; Stahl 1986, 1993; Watson 2005a, 2010). In recent years, debates have arisen over the relationships between the Kintampo and the preceding hunter-gatherer Punpun populations, and much of the discussion has revolved around how best to characterize the nature of the subsistence practices of both traditions (Watson 2005a, 2005b, 2010; Stahl 2005). While some consider the Kintampo to most likely represent the migration of northern Sahelian agro-pastoralists (Davies 1962, 1980; Watson 2005a, 2010), others have emphasized the continuity between the groups, arguing that Sahelian domesticates were incorporated into existing indigenous subsistence practices (Casey 2000; 2002; Posnanasky1984; Stahl 1985a, 1985b; Stahl 1993).

2.5.1 Punpun

Despite the most recent attempts to distinguish between the Punpun and Kintampo occupations (Watson 2005a, 2010), our understanding of Punpun material culture is limited (Casey 2000; Stahl 1993; Watson 2005a, 2010). The Punpun Tradition was first defined through archaeological work at the Kintampo rockshelter sites, K1 and K6 (Figure 2.7) (Rahtz and Flight 1974, Stahl 1985a, 1985b). While the dates generally assigned to Punpun materials, 4228-3485 cal. BP (Stahl 1994), pre-date the range associated with the Kintampo c. 3600-3200 BP (Watson 2005a: 4), a period of overlap is evident. (Stahl 1985a; Watson 2005a, 2010). Unfortunately, Punpun remains have only been recovered from contexts in which they were mixed with Kintampo material culture, even with the most recent archaeological work at the Boase sites (Figure 2.4) (Watson 2005a; 2008). Given the contemporaneous nature of occupations at these sites, it is possible that a clear stratigraphic separation may never be established.

Figure 2.7 Map of select Punpun and Kintampo sites



Apart from recent ceramic studies (Watson 2005a: 15; 2008), Punpun material assemblages have received little attention in comparison to the material culture of the Kintampo. However Punpun remains can be generally characterized by quartz microliths and decorated ceramics, which are different from Kintampo ceramics in their shape, decoration, and manufacture (Watson 2005a: 11-15). The low quantities of these ceramics suggests that these had only a limited role in food storage and preparation, and from the lack of non-portable grinding stones, a highly mobile lifestyle has been suggested for the Punpun (Stahl 1993, 1994).

Direct subsistence evidence for the Punpun phase comes from the K1, K6, and B-sites. In Stahl's re-excavation at K6 (1985), an abundance of land snails shells, savannah-woodland fauna, and *Celtis* sp. seed husks were recovered. These suggested intense and perhaps seasonal exploitation of resources at the rockshelter (Flight 1976; Stahl 1985b). Stahl also reported the remains of oleaginous endocarp from oil palm and incense tree (Stahl 1985a). Similar findings of incense tree and oil palm were also reported from the B-site excavations, with oil palm becoming increasingly important over time (D'Andrea et al. 2006; Stahl 1985, 1993).

In summary, the Punpun remains the only known non-Kintampo LSA populations in Ghana outside of Bosumpra, where the material culture appears to be distinct from that of both the Punpun and the Kintampo (Watson in preparation). Scholars have interpreted Punpun sites as indicating seasonally mobile groups of hunter-gatherers. Ceramics, while present, appear to have had limited use, which is consistent with a more mobile lifestyle. From the deep stratigraphic deposits at rock shelters such as K6, it seems likely that rock shelter sites saw frequent, seasonal reoccupation. Various wild fauna were hunted from the surrounding forests, wild plant resources were also extensively exploited, including the oil-fruits of incense tree and oil palm, with oil palm perhaps emerging as a more important resource and potential cultivar by the period associated with the Kintampo Tradition.

2.5.2 Kintampo

Dating to 3,600-3,200 BP, Kintampo Tradition sites are found distributed throughout modern day Ghana, ranging from the Gambaga escarpment in the north to the southern coastline. Additional traces of Kintampo material culture have also been found in western Togo (de Barros 1983) and eastern Côte d'Ivoire (Chenorkian 1983), although no Kintampo materials have been identified further north in Burkina Faso (Watson 2005a). Kintampo sites are found across the full range of ecological zones in Ghana. Northern Kintampo sites such as Birimi (Figure 2.7) are located in a drier wooded savannah environment, and sites in southern and central Ghana like the K- and B-sites are found in more humid forest-transition habitats. Approximately 50 Kintampo sites have been located, mostly from surveyed surface scatters, and while only 20 of these sites have been excavated, a general semi-sedentary settlement pattern has emerged of lowland, riverine open sites and upland rocks shelter sites, which are found in southern Ghana (Watson 2008: 138; 2010).

The characteristic Kintampo material assemblage is surprisingly homogenous despite such geographic and ecological diversity (Watson 2008), and this has been argued to be an indication of more developed communication networks between Kintampo regions (Stahl 1993).

Although regional variation can be seen in certain types of artifacts (Casey 2000), this diversity likely shows a degree of flexibility in Kintampo subsistence practices within Ghana's different ecological zones (Casey 2000, 2005; D'Andrea et al. 2001; D'Andrea and Casey 2002; Stahl 1993). Kintampo material culture is characterized by the presence of daub architecture, geometric microliths, ground stone axes, grinding stones, rasps, ceramics, and decorative objects (i.e., figurines, beads, and bracelets) (Anquandah 1993: Casey 2005; Dombrowski 1980: Stahl 1985a, 1985b; Watson 2005a).

Kintampo sites consist of both rock shelter and open-air sites, and it is worthwhile to note that no Punpun open-air sites have been found. Kintampo open-air sites provide archaeological evidence for the construction of semi-permanent structures, suggesting decreased residential mobility (Casey 2005: 235; Stahl 1985, 1993; Watson 2005a, 2010). Evidence for interregional trade networks has also been proposed based on the presence of exotic stone and shell materials (Casey 2000; Stahl 1993, 2005; Watson 2005a, 2010). Increased amounts and variety of Kintampo ceramics and the greater presence of grinding stone technologies have all been suggested to show changes in subsistence practices and more intense processing activities during the Kintampo Tradition (D'Andrea et al. 2006; Stahl 1993).

The earliest plant and animal domesticates in Ghana are known from Kintampo assemblages. While only recovered in very limited quantities, faunal remains of ovicaprines and cattle (*Bos* sp.) recovered from Ntereso, K6, and the Boase sites are the earliest in sub-Sahelian West Africa (Carter and Flight 1972: 280; Gautier and Van Neer 2005; Stahl 1985a: 138-142, 1985b: 24, 1993: 265; Watson 2005a: 6-7). However the majority of Kintampo faunal remains belong to wild species including duiker (*Cephalophus* spp.), royal antelope (*Neotragus cf. pygmaeus*), baboon (*Papio* sp.), giant (*Cricetomys* spp.) and cane (*Thryonomys swinderianus*) rats, and snails (*Achatina achatina* in particular) (Gautier and Van Neer 2005: 198; Stahl 1985b: 139-140). Increasing amounts of certain species, particularly rats, that are associated with disturbed habitats, may suggest more permanent human habitation and increasing disturbance of the forest vegetation at these times (Casey 2005; Stahl 1985, 1986, 1993).

Macrobotanical studies of Kintampo macrobotanical assemblages indicate that the Kintampo exploited a wide range of wild and domestic plant resources. However, it remains unclear to what extent domestic species were part of Kintampo subsistence base and thus often difficult to classify the Kintampo within traditional forager or farmer frameworks (Casey 2005; D'Andrea et al. 2006, 2007; Logan and D'Andrea 2012). Assemblages from Birimi in northern Ghana indicate the local cultivation of the non-indigenous pearl millet (D'Andrea and Casey 2002; D'Andrea et al. 2001). The cultivation of domestic millet would have provided a vital reliable vegetable food in this region with a pronounced dry season, and it would have provided a reliable carbohydrate staple for a diet that mostly consisted of wild foods (D'Andrea and Casey 2002). The clearing of fields would have encouraged settlement, creating new foraging opportunities of volunteer plant species. Cleared fields would also have attracted small wild animals which could be hunted (Casey 2005: 238). Small quantities of the indigenous domesticate cowpea, as well as a single pearl millet grain have also been recovered from the K6 and Boase sites in central Ghana (D'Andrea et al. 2006).

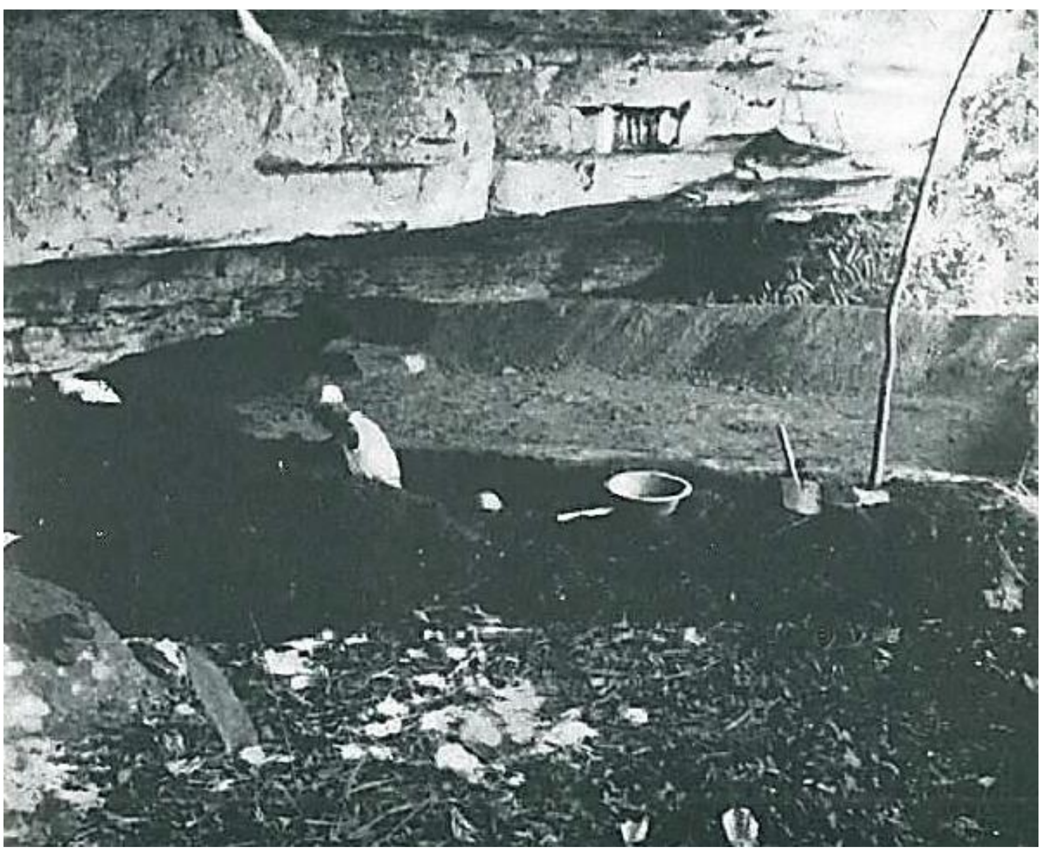
Remains of tree-fruits, including hackberry (*Celtis* sp.), incense tree and oil palm, as well as various legumes (Fabaceae) have been argued to show a continuous and locally adapted exploitation of wild plant resources by Kintampo groups (D'Andrea et al. 2006; Logan and D'Andrea 2012; Stahl 1985b: 141). As previously mentioned, remains of fragmented oil palm endocarp from the K6 and B-sites also indicate the intense processing and perhaps the practice of a form of arboriculture by Kintampo populations c. 3400 BP (Casey 2002: 150; D'Andrea et al. 2006; Logan and D'Andrea 2012).

In summary, the archaeological evidence of subsistence practices for the Kintampo Tradition clearly reflects the introduction of both domesticated cattle and pearl millet into Ghana from Saharan and Sahelian regions. This may indicate that the presence of the Kintampo Tradition in the terminal LSA reflects the movement of a distinct population of food-producers into Ghana in these periods. However, other scholars suggest, that the limited presence of domesticates and the consistent use of similar indigenous wild species by both the Punpun and the Kintampo groups, may instead indicate only a limited integration of domesticates into pre-existing subsistence practices in the terminal LSA. Turning now to a brief overview of the archaeological evidence from the Bosumpra, as neither Punpun or Kintampo material culture were encountered, the rockshelter is one of the most promising place to investigate some aspects of subsistence practices, which as has been discussed in the preceding sections, have proven controversial in Ghana in the terminal LSA.

2.6 Revisiting Bosumpra: Forest Occupations of Ghana Project

The site of Bosumpra (Figure 2.5), a roughly 240 m^2 rock shelter, is one of a series of sandstone caves and rock shelters found along the eastern slopes of the Kwahu Plateau. The shelter was formed between two sandstone formations by the mechanical action of water which seeps from the rock in the wet season (Shaw 1944: 1, Watson in preparation). Within the shelter, the floor is lowest in the center and slopes upwards towards the edges. Sediments within the shelter are composed of a complex mixture of sandy silt deposits from the natural disintegration of the walls and ceiling, as well as human introduced wood charcoal, endocarp, seeds, bones, shell, and inorganic materials including ceramic and stone artifacts.

Figure 2.8 'Bosumpra' Cave (photograph by Shaw: 1944)



The site of Bosumpra has played a prominent role in our understanding of early LSA archaeology in Ghana, bearing the distinction of being one of the first excavated and published sites, and producing some of the earliest LSA material culture in Ghana. It also remains one of the only excavated LSA sites in the forested regions of Ghana. The first excavations at Bosumpra were directed by Thurston Shaw in the early 1940s, who excavated a *c.* 1.2 x 8.2m trench to a depth of approximately 2 m (Figure 2.8). At Bosumpra, Shaw found rich deposits which he divided into two occupation phases (Shaw 1944). The earlier phase, characterized by abundant quartz microliths, celts, and ceramics, Shaw considered part of a regional Guinea Neolithic industry; the later phase he considered to belong to a distinctly different later "Akan" occupation phase.

Because Shaw's work was conducted before the advent of radiocarbon dating, a second small-scale excavation was undertaken by A.B. Smith (1975) to obtain dates. Smith did not publish any stratigraphic information beyond depths, nor did he excavate the same area or to the same depths as Shaw. However, Smith's work established that forests of Ghana were occupied at least as early as 5370 ± 100 BP (1975:179), and because this date was obtained in association with ceramics, it was long used as the basis for the regional division of LSA occupations into aceramic and ceramic phases (Shaw 1985).

Of particular importance to my own study, Smith suggested that incense tree was an important Early Holocene forest resource, based on the presence of incense tree endocarps at Bosumpra from an occupation layer dating to 5370 ± 100 BP (Smith 1975:179). Although based on limited and largely undated data, Smith hypothesized that the importance of incense tree as a food plant declined throughout the Holocene, and that it was eventually replaced by oil palm. He observed that incense tree endocarp alone was present at Bosumpra in deposits 90-100 cm deep, that it was found alongside oil palm endocarp 90-50cm deep, and that it was completely replaced by oil palm 770 ± 75 BP in layers above 50cm (Smith 1975:179).

Excavations at Bosumpra were resumed in 2008-10 under the direction of Dr. Derek Watson (University of Ghana) primarily to address questions relating to the subsistence, mobility, and social organization of pre-Kintampo LSA groups, particularly those occupying forested habitats. This work formed a component of a larger investigation entitled 'Forest Occupations of Ghana Project' (Figure 2.9). Watson recorded a similar stratigraphic sequence as described by Shaw (1944: 2) (Watson in preparation) but with a far longer occupation sequence, beginning in the 13th millennium cal. BP (Watson in preparation). Occupations at

Bosumpra over the Holocene were mostly likely intermittent, however the chronological sequence established across the site (Table 2.1) is the longest sequence of human habitation yet reported for Ghana and amongst the longest in West Africa.

Figure 2.9 2008-2010 Excavations at Bosumpra (photograph by Watson)

Within the roughly 20 x 60 meter rock shelter, twelve 1.5m x 1.5m units were excavated to a depth of almost 2.5 m in 10 cm arbitrary spits (Figure 2.10). This was done to ensure stratigraphic control over the naturally complex deposits of the rock shelter. Following excavation, seven stratigraphic layers were established (Figure 2.11), which matched with the stratigraphic divisions of upper and lower layers originally reported by Shaw (1944: 1-2). Although limited disturbance was suggested by the presence of roots and termite mounds, there was no evidence of significant stratigraphic disturbance beneath Layer 4 (Watson in preparation). In the lowest layer, Layer 1, all excavated spits were further divided into eight horizons (Figure 2.11).

Figure 2.10 Excavated Units at Bosumpra (modified from Watson in preparation)

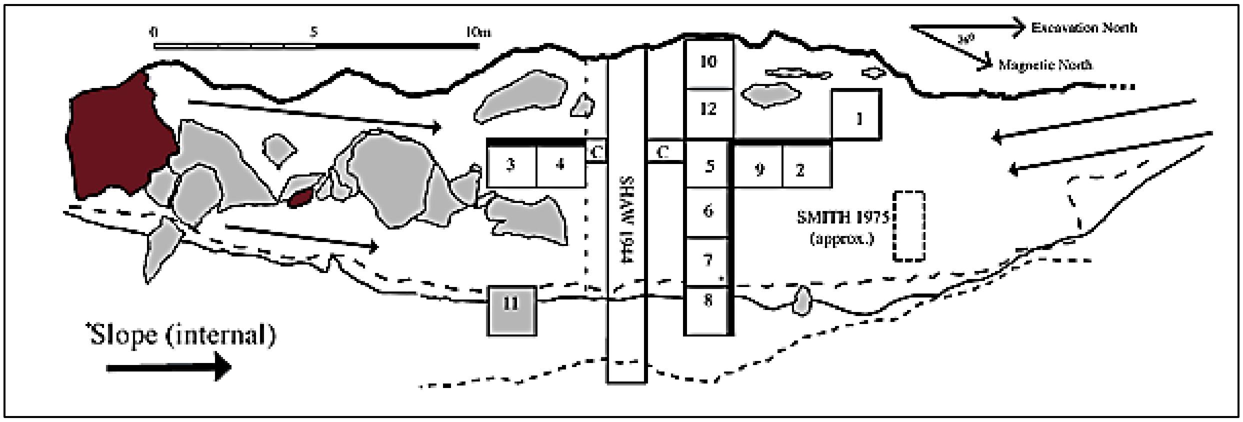
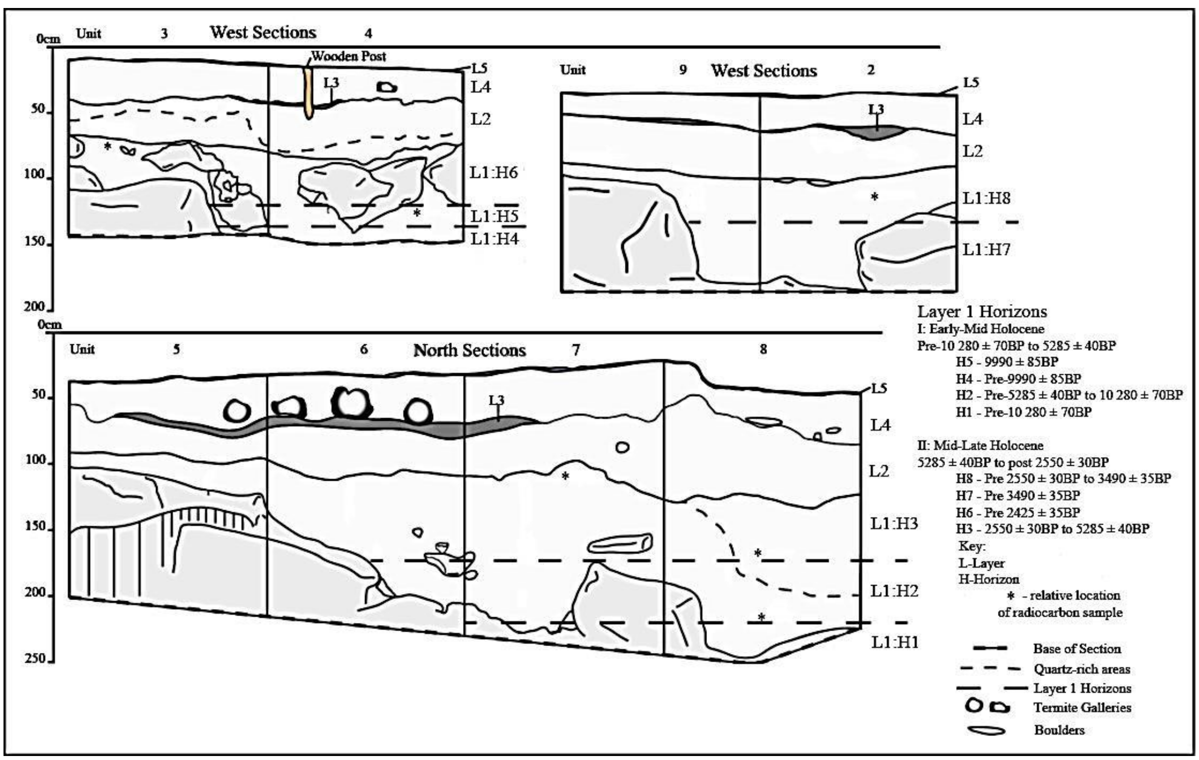


Figure 2.11 Stratigraphic profiles 2008-2010 (modified from Watson in preparation)



The material culture assemblage at Bosumpra is dominated by white quartz, greenstone, mudstone, shale, and ochre and the majority of recovered lithics comprise geometric microliths made from a white quartz material that was likely manufactured on-site from the parent material of the rock shelter (Watson in preparation). It is possible that the availability of this white quartz at the rockshelter was a major reason for the occupation/exploitation of the site (Watson in preparation). The other materials, shale, greenstone, mudstone, and ochre, are not found within Bosumpra or within its immediate area, but are available in the Kwahu Plateau and are present from the earliest occupation periods (Watson in preparation).

Table 2.1 Select Radiocarbon Sequence from Bosumpra (Watson in preparation)

Sample	Material	Unit	Layer	Horizon	Type	Radiocarbon Age	cal. AD/BC (99.7%)	cal. BP (99.7%)
Ua-36775	Palm Kernels	Unit 2	3		AMS	365 ± 35	AD 1440-1645	510-305
Ua-36774	Charcoal	Unit 3	2		AMS	465 ± 35	AD 1324-1619	627-331
Ua-37248	Charcoal	Unit 3	1	6	AMS	2425 ± 35	763-397 BC	2712-2346
Ua-36776	Charcoal	Unit 7	1	3	AMS	2550 ± 30	808-537 BC	2757-2486
Ua-37250	Charcoal	Unit 2	1	8	AMS	3490 ± 35	1948-1686 BC	3897-3635
Ua-36777	Charcoal	Unit 8	1	3	AMS	5285 ± 40	4318-3972 BC	6267-5921
Ua-37247	Charcoal	Unit 4	1	5	AMS	9990 ± 85	10,046-9251 BC	11,995-11,200
Ua-36778	Charcoal	Unit 8	1	2	AMS	10280 ± 70	10,576-9669 BC	12,525-11,618

2.6.1 Early Holocene Occupations at Bosumpra

Evidence about the earliest occupation phases at Bosumpra come from the lower horizons (5,4,2 and 1) of Layer 1, and include hand-made, low-fired ceramics, and celts of non-local greenstone (Watson in preparation) The ceramics, decorated with chord wrapped roulette and a channelling motif, are highly fragmented but certain rim sherds suggest large, open-aperture vessels (Watson in preparation). The limited distribution of ceramics in the lowest layers at Bosumpra suggests that this was a rare technology at the earliest occupation phases, and it is possible that the ceramics in this phase may not have had a utilitarian purpose (Watson in preparation). Overall the material culture recovered from Bosumpra indicates that the site was used for the manufacture of celts and other tools, and that throughout the occupation of the site in the Early Holocene tools were manufactured, used and maintained at the site (Watson in preparation).

2.6.2 Mid-Later Holocene Occupations at Bosumpra

In the upper horizons (3,6,7, and 8) of layer 1, dating 5285 to 2550 BP, tools of local and non-local raw materials continue to make up a large portion of the assemblage recovered at Bosumpra, with a majority of tool materials concentrated near the entrance of the rock shelter (Watson in preparation). Quartz geometric microliths and bifacial cores continue to dominate the assemblage, but unifacial points also appear in this period. Celts are also frequent, becoming more diverse in form. Overall, there is an increase in the diversity of non-site, non-local materials in this period, and several new tool forms appear, such as ‘pestles’ which might indicate new methods of preparation of food (Watson in preparation). The frequency of ceramics increases in this period, although the majority of sherds were concentrated within Unit 6 Horizon 3. Apart from the addition of a new surface treatment of burnishing, ceramics found from this period largely resemble those from earlier occupation layers.

2.6.3 Later Holocene Occupations at Bosumpra (Post 2550 BP)

In stratigraphic layers 2 and 3, there are indications at Bosumpra of significant changes in the site-formation process of the shelter likely related to regional environmental changes and perhaps to human activities as well (Watson in preparation). The diversity and density of tools and associated manufacturing debris decrease, which may reflect broad changes in human land-use and settlement patterns. However, although rare, the continued presence of quartz tools and fragments indicates that microlithic production continued after the introduction of metallurgy, which appeared in Ghana sometime between 2500-1500 BP (Stahl 1994), and the continuation of at least sporadic occupation of Bosumpra throughout this long period (Watson in preparation). Ceramic materials appear similar to those found in the Middle Holocene (Layer 1), although there is an increase in the diversity of decorative techniques and motifs. Changes in form are also apparent with the appearance of carinated vessels and new forms of the rims commonly found on wide aperture vessels in Layer 1 (Watson in preparation).

2.7 Summary

The Bosumpra rockshelter provides some of the earliest evidence for human occupation in the tropical forests in Ghana, with an unusually long sequence of occupations from the Late Pleistocene until modern times. Overall, the distribution and chronological resolution of materials at Bosumpra indicate a degree of spatial organization of activities related to tool manufacture, and possibly of cooking and food storage at the shelter (Watson in preparation). There appears to be continuity in the lithic, ceramic and other technologies tools, technologies, and associated activities at Bosumpra throughout the early, mid, and later Holocene. However, the overall increase in the quantities of materials as well as an increase in the diversity of forms and the raw materials may offer some indication of changing in behavior in relation to the use of Bosumpra and interactions with the surrounding regions.

3. FIELD AND LABORATORY METHODS

3.1 Introduction

In this chapter I describe the field and laboratory methods used in the collection, recovery, analysis, and identification of the macro-botanical materials from Bosumpra. These methods were guided by the research questions seeking to understand the nature of plant use over the Holocene, and in particular to test Smith's (1975) hypothesis about a shift from the use of incense tree to oil palm tree-fruit resources in the later Holocene. I discuss the sampling and identification strategies used for the analysis of seed and nutshell remains, as well as for the small wood charcoal analysis that was completed. Finally, I explain my quantitative approach for the analysis and interpretation of the macrobotanical data.

3.2 Field Methods

3.2.1 Sampling Strategies

In previous excavations at Bosumpra (Shaw 1944; Smith 1975), no systematic sampling for macrobotanical materials was completed. As such, in this study, it was decided to use a column sampling approach that collected a standard (10 l) soil sample from every reliable context from Layers 1, 2, and 3 for flotation (Table 3.1). All samples analysed for this thesis were collected during excavations that took place at Bosumpra between June 2008 and December 2010 directed by Dr. Derek Watson.

I have taken the radiocarbon dates and the stratigraphic levels and horizons reported by Watson (Table 2.1) and used them to divide the macro-botanical samples into three chronological groups spanning the entire occupation of Bosumpra from the Early to Later Holocene (Table 3.1). The earliest samples, representing occupations in the Early and Middle Holocene, represent spits from the lowest Horizons of Layer 1, dating from *c*. 10,280-5,285 uncal. BP. The second phase, from Middle to Late Holocene *c*. 5,285-2,500 uncal. BP consists of samples from the upper Horizons of Layer 1. Finally, samples from Layers 2 and 4 make up the latest Holocene group, dating post 2,500 BP.

Table 3.1 Analyzed Light Fraction Samples

PHASE	LAYER	HORIZON	Unit 1	Unit 2	Unit 3	Unit 4	Unit 5	Unit 6	Unit 7	Unit 8	TOTAL
Phase III: Post 2550 BP	3		2	2	2	1	2	1	1	2	**41**
	2		1	4	2	4	2	4	3	8	
Phase II: 5285-2550 BP	1	8	4	2							**48**
		7	2	7							
		6			2	4					
		3					6	6	10	5	
Phase I: 10,280-5285 BP	1	5			1	1					**23**
		4				2					
		2						4	6	4	
		1							1	4	
TOTAL			**9**	**15**	**7**	**12**	**10**	**15**	**21**	**23**	**112**

3.2.2 Recovery Methods: Flotation and Hand Collection

Data relating to ancient plant use were obtained from the analysis of light fractions and hand-collected macrobotanical remains. Soil samples were processed with an Ankara flotation machine (Figure. 3.1) following standard palaeoethnobotanical flotation procedures (Pearsall 2000). Coarse (or heavy) fractions were collected with a 500 micron mesh screen, and the light fractions using a 250 micron mesh screen. Machine assisted flotation and the use of appropriately fine mesh screens allowed for the capture of small but dense remains in addition to providing more consistent and gentle collection of light fraction remains. The consistent recovery of small and delicate 0.25-0.5mm seeds such as *Zaleya pentandra* identified during the microscopic analysis of flotation samples suggests that the recovery methods were successful in minimizing the loss and potential damage to the macrobotanical remains. In addition to bulk light fraction samples, other macrobotanical samples were also collected by hand for archaeobotanical analysis. These consisted of large, well preserved, and diagnostic remains of various tree fruits and wood charcoal specimens. In total, 112 light fraction samples were collected and analysed from the 2008-2010 excavation seasons at Bosumpra from Units 1-8 (Table 3.1).

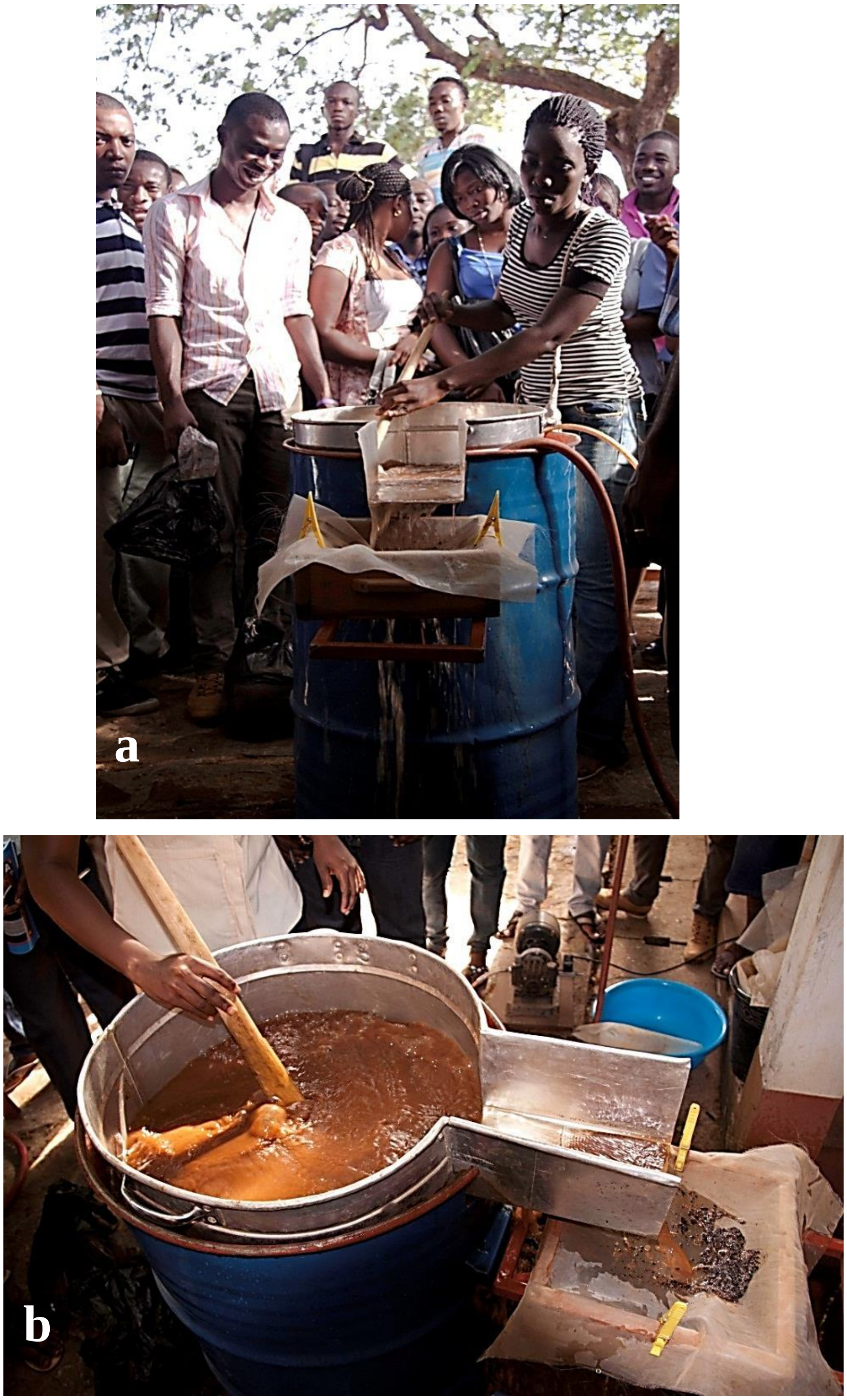


Figure 3.1 Students conducting flotation of soil samples with an Ankara flotation machine (photo by Watson.): (a) agitation of sample by pumping water action and additional stirring; (b) light fraction macrobotanical materials carried by flow of water and caught in fine 250 micron mesh.

3.3 Laboratory Methods

3.3.1 Sorting

Light fractions were analyzed in the Archaeobotany Laboratory at the Department of Archaeology, Simon Fraser University. All samples were sorted, identified, and quantified according to standard archaeobotanical procedures in order to minimize biases, and maximize the information available from the macrobotanical assemblage (Hastorf and Popper 1988; Pearsall 2000).

The weight (g) of each light fraction flotation sample was measured and recorded prior to analysis. All samples were then sieved using the following standard geological sieves with screen sizes (in mm): 2.0, 1.0, 0.5, and 0.25. For samples that weighed more than 20 g, an additional 4.00 mm screen was used. This was done to facilitate viewing while sorting, and to allow for easier subsequent selection of wood charcoal fragments for identification. All materials were examined under a Motic SMZ-168-BP binocular light microscope with a magnification range of 10-50x. All materials 1.00 mm or larger were completely sorted, and rootlets, gravel, and modern debris were removed. When present, all remains of charcoal, nutshell, endocarp, seeds, and other unidentified charred remains were separated from materials larger than 2.0mm. Both fragment counts and weights (g) were recorded for these materials. The remaining fractions under 1.0 mm were scanned only for seeds using a higher magnification.

In each sample, all well preserved whole, or nearly whole seeds were identified or removed as ‘unknown’ for future identification. ‘Unknown’ here refers to whole or nearly whole seeds which have sufficiently preserved features to enable identification, but which are unable to be identified at this time, generally because of limited reference collections. Unidentifiable seeds, which are seeds or seed fragments which are poorly preserved or otherwise unlikely to be identifiable, were also removed and recorded. One final category of macrobotanical materials recovered that requires further explanation is ‘Unidentified Charred Remains’, which includes charred plant materials that are neither wood charcoal nor seeds. All data were recorded on a flotation form and entered into a Microsoft Excel spreadsheet for further analysis. Digital images of tree-fruit endocarp, wood charcoal, and seeds were taken using a Leica DFC425 Digital Camera and SW kit attached to the third ocular of a Lieca MZ6 microscope.

3.3.2 Identification

When possible, remains of well-preserved seeds and fruits have been identified to family or genus level. If sufficient diagnostic features could be found and when all other possible candidates could be excluded, the identification to species level was deemed secure. The personal comparative collection of Catherine D'Andrea, housed in the Archaeobotany Laboratory, Department of Archaeology, Simon Fraser University was used for seed and endocarp identification. In addition online published reference materials were also used, including the well-illustrated reference materials by Kahlheber (2004 vol. 2: 1-225) and D'Andrea et al. (2001; 2006; 2007).

In addition to seeds and endocarp, wood charcoal was one of the most abundant types of macrobotanical material recovered from Bosumpra. As the analysis of macrobotanical remains in this thesis primarily focused on questions about subsistence, most attention was given to the identification of charred seeds, fruit, and nutshell remains. However, as wood charcoal remains can provide information about the microenvironment surrounding a site, a small wood charcoal analysis was completed. Wood charcoal fragments captured in a 2mm sieve, and some collected by hand during excavation, were selected and examined from samples from each of the broad occupation phases (Table 3.2) to provide preliminary palaeoenvironmental data about the region surrounding Bosumpra. Identifications were completed using the reference collections housed at the University of Frankfurt Archaeobotanical Laboratory, and the resources of the online InsideWood Database (InsideWood 2004-onwards; Wheeler 2011). As only a small wood charcoal study was planned, analysis was limited to 15 fragments from eight samples (Figure 3.3, with a total of 120 fragments analysed.

Table 3.3 Samples Selected for Wood Charcoal Analysis

DATE RANGE	LAYER	HORIZON	U4	U6	U7	U8	TOTAL
post 2500 BP	4					597	**2**
	2					598	
5285-2500 BP	1	3		571	582	622, 616	**4**
10,280-5285 BP	1	5	550				**2**
		2			603		
TOTAL							**8**

3.3.3. Quantification and Data Analysis

While raw counts and weights were recorded for each sample (Appendix B), additional quantification, in the form of ubiquity measures and ratios, were calculated in this study. For palaeoethnobotanical data, quantification can aid in reducing potential biases related to the differential preservation and deposition of plants remains at the site. Differential preservation of plant remains arises from variations in plant anatomy and the likelihood of surviving processing and charring, as well as post-depositional factors, such as disturbance and scavenging (Pearsall 2000; Popper 1988).

3.3.3.1 Ubiquity

Data from the analysis of hand and light fraction macrobotanical remains were used to generate ubiquity scores. Ubiquity, or presence analysis, is a commonly used method of quantification that determines the number of samples in which particular taxa are present or absent. The resulting frequency score then can provide independent contexts a relative (not absolute) picture of the importance of taxa within a group of samples (Popper 1988). While this provides only a general picture of change over time, ubiquity measures can show broad patterns or trends in the data.

With ubiquity measures, it is important to note the difficulties with interpreting the absence of taxa, especially when there is a range in the relative durability amongst the recovered botanical materials. While tree fruit endocarp and grains such as millet have a relatively high chance of surviving burning, beans such as cowpea are morphologically more prone to fragmentation and less likely to survive the charring process (Gasser and Adams 1981:183-184).

3.3.3.2 Ratios

As raw counts or weights of macrobotanical remains often obscure interesting patterns in the data because of differences in the total numbers of samples or the amounts of soil floated, archaeobotanists frequently use ratios to standardize their data (Miller 1988; Pearsall 2000). Macrobotanical data from the analysis of light-fraction samples at Bosumpra were converted to both density and comparison ratios, following the example of Miller (1988) and Popper (1988) in order to compare patterns of plant remains over the long occupation sequence at Bosumpra.

In order to assess the changes in the quantities of oil palm and *Canarium* tree-nut endocarp and over the long sequence of occupations at Bosumpra, density ratios were calculated by taking the weight of endocarp per volume of soil processed by flotation, which allowed for the comparison of endocarp and wood charcoal densities per liter of soil over time. Percentages were also used to compare the relative importance of *Canarium* to oil palm and to test the observation of Smith (1975) about the replacement of *Canarium* with oil palm over time. The percentages of each taxon (based on weight) were compared as percentage of *tree-fruit endocarp : total endocarp recovered*. To measure the intensity of burning activities and potentially occupation intensity over time, density ratios were also calculated for wood charcoal measuring wood charcoal (g) per liter of soil floated. All density and weight measurements are reported to two decimal places.

3.4 Summary

In order to answer questions about continuity and change in the subsistence practices of the LSA occupants of Bosumpra, I used macrobotanical data collected through my analysis of flotation samples from the 2008-2010 excavations at the rock shelter. In the following chapter, the results of the macrobotanical analysis will be given, including both a more general overview of the charred botanical materials as well as discussion of remains by chronological phase at Bosumpra.

4. Results: Plant Remains from Bosumpra 10,280-2500 BP

4.1 Introduction

This chapter reports on the results of the analysis of the light fraction macrobotanical samples from Bosumpra rock shelter, including the results of a small wood charcoal study. Because there were no measurements of sediment volume available for the wood charcoal hand collected remains, densities and other measures were calculated only for the 112 samples processed by flotation. Given the generally low abundance, and very low weight of charred seeds, frequently less than 0.01g, all seed results are reported by count. All other macrobotanical remains are reported by weight, except for the remains of identified wood charcoal which are reported by fragment count.

The archaeobotanical findings are discussed as precisely as possible in terms of taxonomic identification. I considered all seeds identifiable if they could be identified to at least family level. When diagnostic features were present, and when all other possible candidates could be excluded, species or possible species (*cf.*) level designations were given for certain taxon. Common names, and Latin names are used throughout (see Appendix A for a full list of all identified plant names in Latin, and English).

Tables 4.1, 4.2 provide a summary of the Bosumpra macrobotanical data (for total counts and weights see Appendix B). A total of seven genera, including two tree fruit species, were identified to genus or species level. Generally the species level identifications were only possible for tree fruit taxa or domesticated seeds. Several wild seeds, with ‘seeds’ in this instance including seed-like fruits (i.e., caryopsis, achenes, etc.), were also identified to genus and possible species level. However, as regional floras and comparative collections for most wild plants in West Africa are often unavailable, many of the seeds analyzed from the light fraction could only able to be assigned to family level

Table 4.1 Endocarp and Wood Charcoal Remains

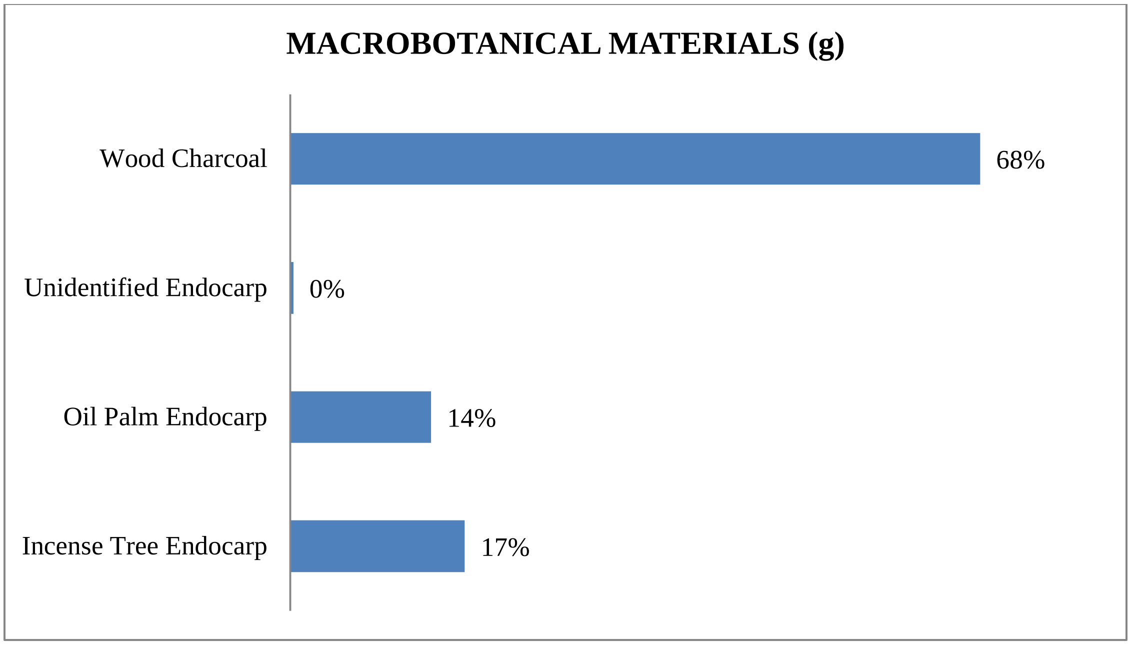
	Phase I 10,280-5285BP	Phase II 5285-2550BP	Phase III post 2550 BP	TOTALS
Number of Samples	n=23	n=48	n=41	**112**
Vol. of Soil Sampled	270	510	460	**1240**
Macrobotanical Remains (g)				
Incense Tree Endocarp	27.11	157.72	39.86	**224.69**
Oil Palm Endocarp	6.67	69.31	105.1	**181.08**
Unidentified Endocarp	0.18	2.85	1.11	**4.14**
Wood Charcoal	28.92	292.42	565.8	**887.14**
TOTAL	**62.88**	**522.30**	**711.87**	**1297.05**

Table 4.2 Seed Remains

	Phase I 10,280-5285BP	Phase II 5285-2550BP	Phase III post 2550 BP	TOTALS
Number of Samples	n=23	n=48	n=41	**112**
Vol. of Soil Sampled	270	510	460	**1240**
Macrobotanical Remains (n)				
Pearl Millet		4	6	**10**
Cowpea		2	1	**3**
Bergia cf. capensis	267	1391	181	**1839**
Cleome cf. monophylla			1	**1**
Zaleya pentandra	1	7	3	**11**
Brassicaceae		1		**1**
Fabaceae	3	5	12	**20**
Poaceae	1	6	8	**15**
Ranunculaceae	5	22	46	**73**
Solanaceae		1		**1**
Unknown		3	1	**4**
Unidentifiable	21	92	131	**244**
TOTAL SEEDS	**298**	**1534**	**390**	**2222**

Wood charcoal makes up the majority by weight (68%) of the total macrobotanical assemblage from Bosumpra, and fragments are present in virtually every sample (Figure 4.1). The remaining macroremains consist mostly of tree-fruit endocarp from incense tree (17%) and oil palm (14%). In addition to wood charcoal and tree-fruit endocarp, a total of 2,222 seeds, including four grains of domesticated pearl, six grains of probable (*cf.*) pearl millet, one specimen of cowpea, and two probable specimens of cowpea were identified (Table 4.2). The average seed density at Bosumpra is low at 1.8 seeds /l.

Figure 4.1 Total Percentages of Light Fraction Macrobotanical Materials (g)



In this chapter, I begin with the results of the macrobotanical analysis at Bosumpra by phase, presenting for each phase the percentage presence of all plant remains, the densities of wood charcoal and endocarp, seed counts, and a description of select identified seed taxa. In the second half of the chapter, the results from the small pilot study of wood charcoal from Bosumpra are presented by phase.

4.2 Macrobotanical Remains from Bosumpra by Phase

4.2.1 Phase I: Early to Mid-Holocene 10,280-5285 BP

Twenty-three archaeobotanical samples dating between 10,280-5285 BP were analyzed, representing 270 l of sediment processed by flotation. Samples from Phase I make up only 5% of the total macrobotanical assemblage, and the average abundance of macrobotanical remains in this phase is low when compared with later phases. For each liter of floated soil, only 0.05 grams of charred plant remains were recovered, with an average seed recovery of 1.10 seeds/l. While there were twice as many samples analyzed from later phases, the differences in the densities of charred plant remains between phases also may reflect changes over time in the amount of burning activities at Bosumpra (Miller 1988).

4.2.1.1 Tree Fruits and Wood Charcoal

Endocarp of two tree-fruit species, incense tree and oil palm, were identified in the Phase I samples at Bosumpra, following the morphological criteria described by D'Andrea et al. (2006:205). Endocarp fragments and incense tree make up 43% of the Phase I macrobotanical assemblage and are present in 78% of the samples (Figure 4.2). The densities of incense tree and wood charcoal are nearly equal in Phase I, (Figure 4.3) although in later phases wood charcoal densities dominate all other types of macro-botanical remain.

Figure 4.2 Percentage presence of charred plant materials in Phase I

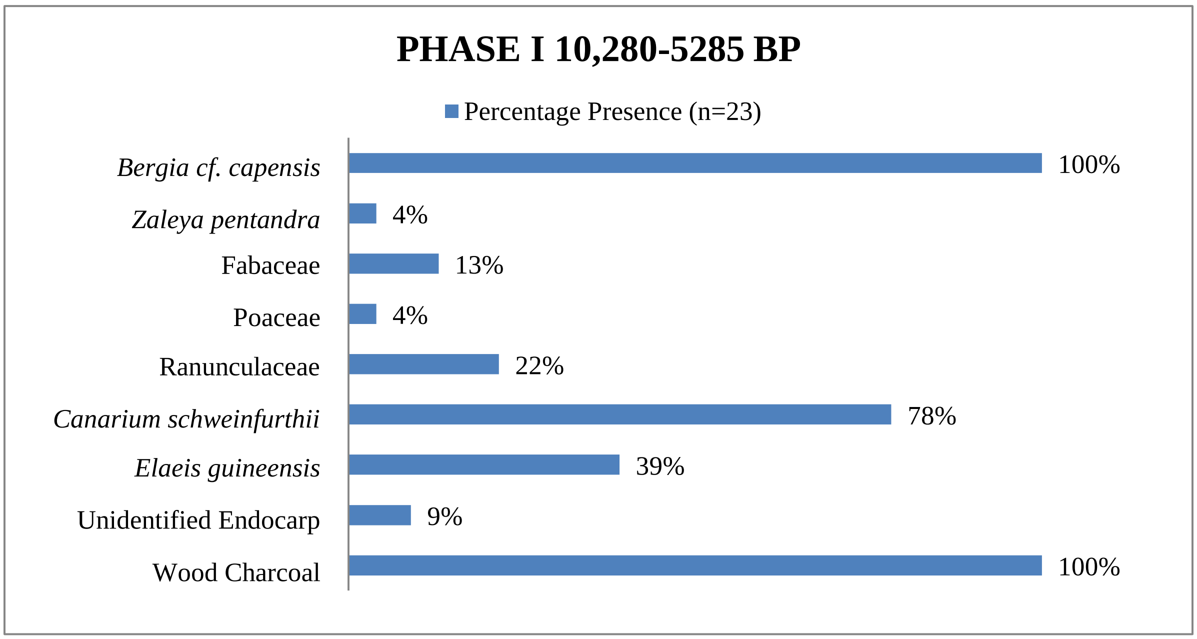
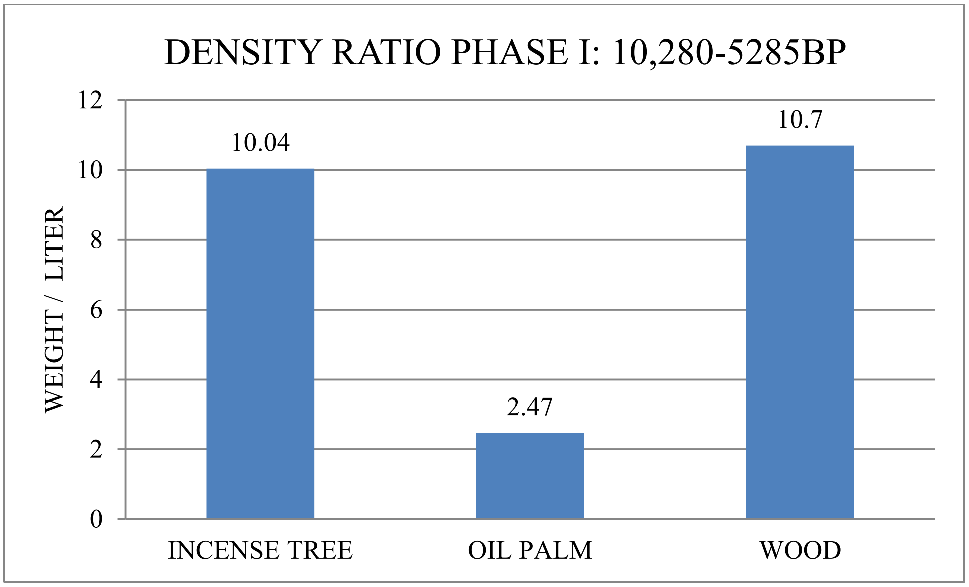


Figure 4.3 Wood and Tree-Fruit Density Ratios: Phase I 10,280-5285 BP



In Phase I, oil palm is present in only 39% of the samples, and constitutes 11% of the flotation samples (Figure 4.2). However, while the density of oil palm is lowest in Phase I, an AMS radiocarbon date of 8410±40 uncal. BP of oil palm endocarp from Unit 8 Horizon 2 is the earliest directly dated archaeobotanical evidence for the use of oil palm in West Africa (Table 4.3).

Table 4.3 Endocarp Radiocarbon dates

Sample	Material	Unit	Layer	Horizon	Type	Radiocarbon Age	cal. AD/BC (95%)	cal. BP (95%)
Beta-343278	Oil Palm Endocarp	Unit 8	1	2	AMS	8410±40 BP	7560 BC, 7550-7540 BC, 7390-7380 BC	9520-9510 BP, 9500-9400 BP, 9340-9330 BP
Beta-343279	Incense Tree endocarp	Unit 8	1	2	AMS	6300±30 BP	5320-5220 BC	7270-7170 BP

In Phase I, 98% of incense tree endocarp remains are concentrated in Units 8 and 7, which are located next to, or just outside the drip line of the Bosumpra shelter. In addition, 95% of the total recovered oil palm and the largest concentration of wood charcoal (79%) are found in Unit 7 alone. This concentration of wood charcoal and burned plant remains is not unexpected, as ethnographic and archaeological studies have often found that burning activities tend to be located near the entrances of rock shelters (Balme and Beck 2002; Walthall 1998).

4.2.1.2 Wild Edible and Weedy Seeds

No domesticated seeds were found in Phase I samples, as would be expected given our current understanding about the location and timing of domestication of pearl millet and cowpea (Manning et al. 2011; D'Andrea et al. 2001, D'Andrea et al. 2007). A few wild edible and weedy species were identified in Phase I samples (Table 4.4), and are described below. However, given the low overall seed counts, and the difficulty with securely identifying seeds to species, it is difficult to provide even basic qualitative data about the ecology, distribution, seasonality, and possible uses for this assemblage.

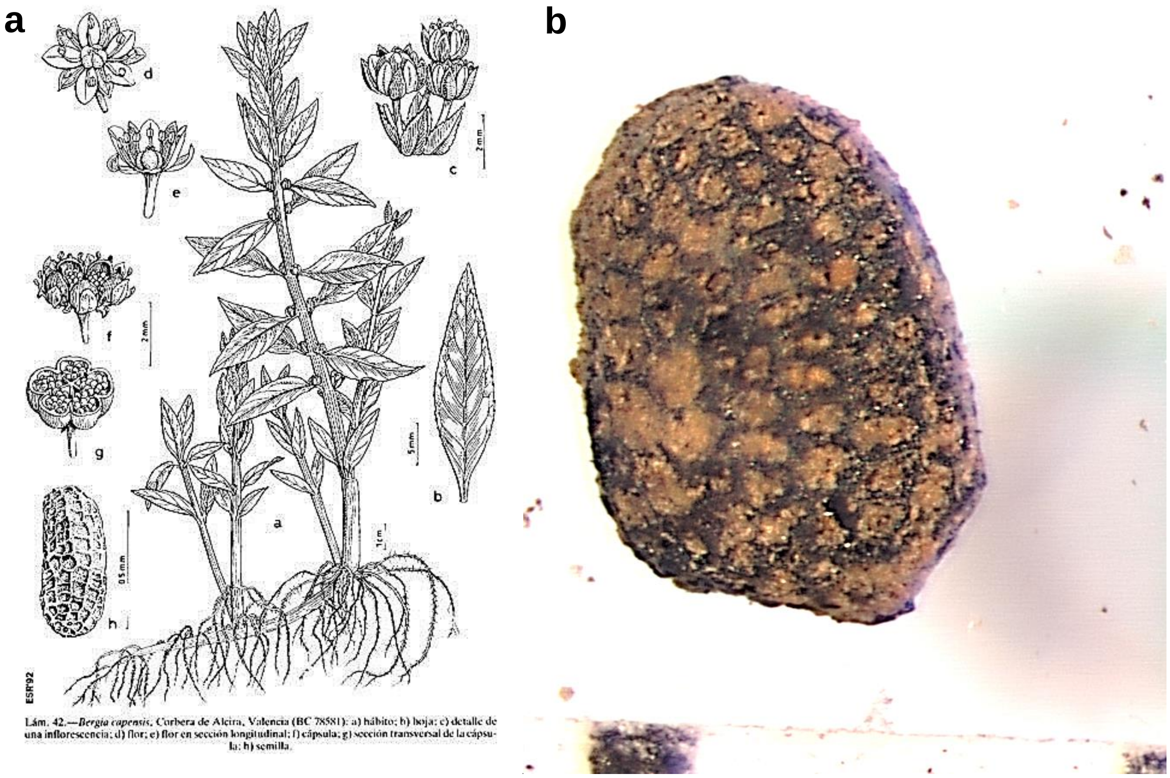
Table 4.4 Phase I: Wild Edible and Weedy Seeds

Wild Seeds								
	Unit	*Bergia cf. capensis*	*Zaleya cf.pentadnra*	Fabaceae	Poaceae	Ranunculaceae	Unidentifiable	**Total Seeds**
Phase I 10,280-5285BP	3	3		2		3		**8**
	4	24	1	1	1		8	**35**
	6	103				1	2	**106**
	7	88				1	4	**93**
	8	49					7	**56**
	Total	**267**	**1**	**3**	**1**	**5**	**21**	**298**

Bergia cf. capensis

Bergia capensis (Linn.) is one of twenty five species of *Bergia* in the small family of Elatinaceae (Figure 4.5). *Bergia* is an aquatic or semi-aquatic herbaceous genus found throughout tropical and temperate regions in the Old World. *B. capensis* is a semi-aquatic species that grows most often in swampy areas, near shallow pools, and riverbanks (AFPD 2008). While *B. capensis* is not today considered to be a source of food, Burkhill mentions the practice in Ghana of collecting *B. capensis* for religious purposes (1985:17).

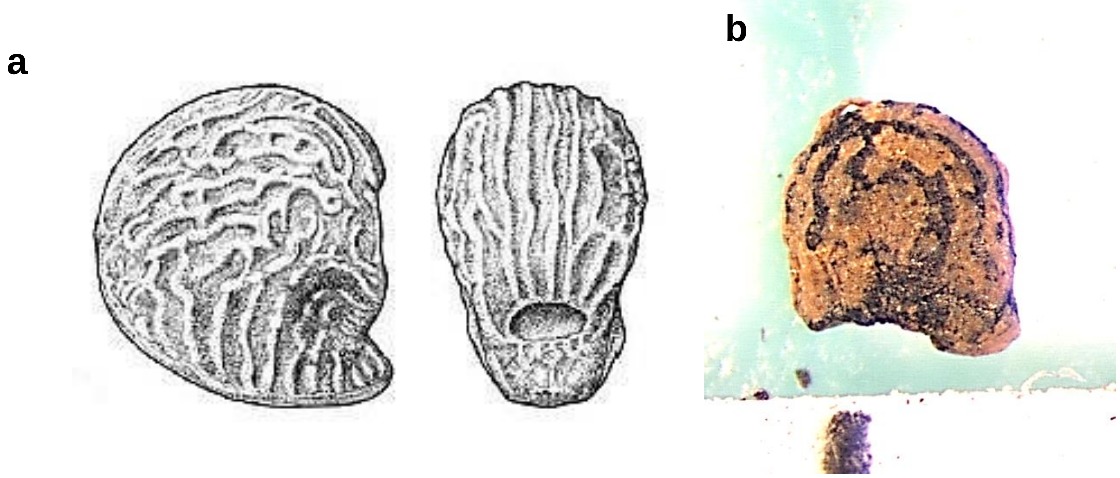
Figure 4.4 **Bergia capensis** ***seed a) modified from Castroviejo 2013; b) image by author***



Zaleya pentandra

One seed of *Zaleya pentandra (L.)* Jeffery, also known as African purslane, in the Aizoaceae family was found in Phase one (Figure 4.6). It is the only species of this genus in Africa (Lebrun and Stork 1991:89). *Zaleya pentandra* is found throughout tropical Africa, most often in open areas of woodlands, along riversides, and in disturbed areas near roads and cultivated fields. Today it is considered both a common weed as well as a useful wild plant that is occasionally collected as a food or medicine (Logan 2012). The leaves of *Z. pentandara* can be eaten as a vegetable or used as a potherb, and as a medicine it has been used to treat for intestinal and digestive problems and headaches (Burkhill 1985: 40).

Figure 4.5 **Zaleya pentandra** ***seed a) modified from Kahlheber 2004; b) image by author***



4.2.2. Phase II: Mid to Late Holocene 5285-2550 BP

Remains from 48 archaeobotanical samples, representing 510 l of floated soil, were analyzed from spits dating between 5285-2550 BP. Samples from Phase II have on average 1.02 grams of macrobotanical material per liter of floated soil, and the highest density of seeds, with an average of 3.04 seeds recovered per liter of processed soil.

4.2.2.1 Tree Fruits and Wood Charcoal

As in Phase I, incense tree is the dominant tree fruit taxon, present in 77% of the samples and making up 30% of the total Phase II assemblage (Figure 4.7). Oil palm constitutes 13% of the total recovered macro-remains, and is present in 46% of Phase II samples. There is a noticeable increase in the density of both tree-fruit species as well as wood charcoal between Phase I and II (Figure 4.8). While incense tree is present in over 75% of the samples in both phases, more than three times as much incense tree was recovered on average in Phase II samples, which is the highest density of incense tree at Bosumpra in any phase (Figure 4.8). With oil palm and wood charcoal, the increase is even more striking, as the density measures for both are five times greater in Phase II samples (Figure 4.8). Wood charcoal alone makes up 56% of the total Phase II macro-botanical assemblage (Figure 4.7)

Figure 4.6 Percentage presence of charred plant materials in Phase II

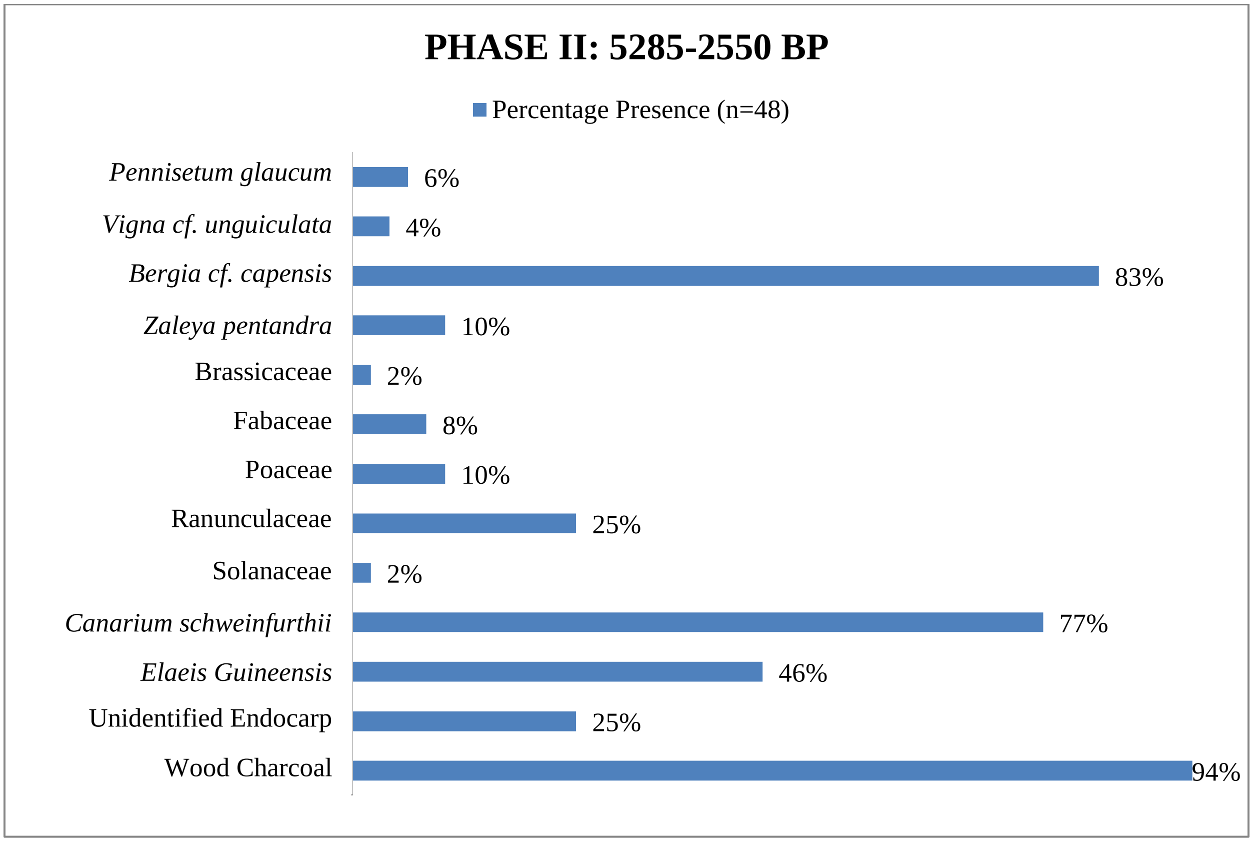
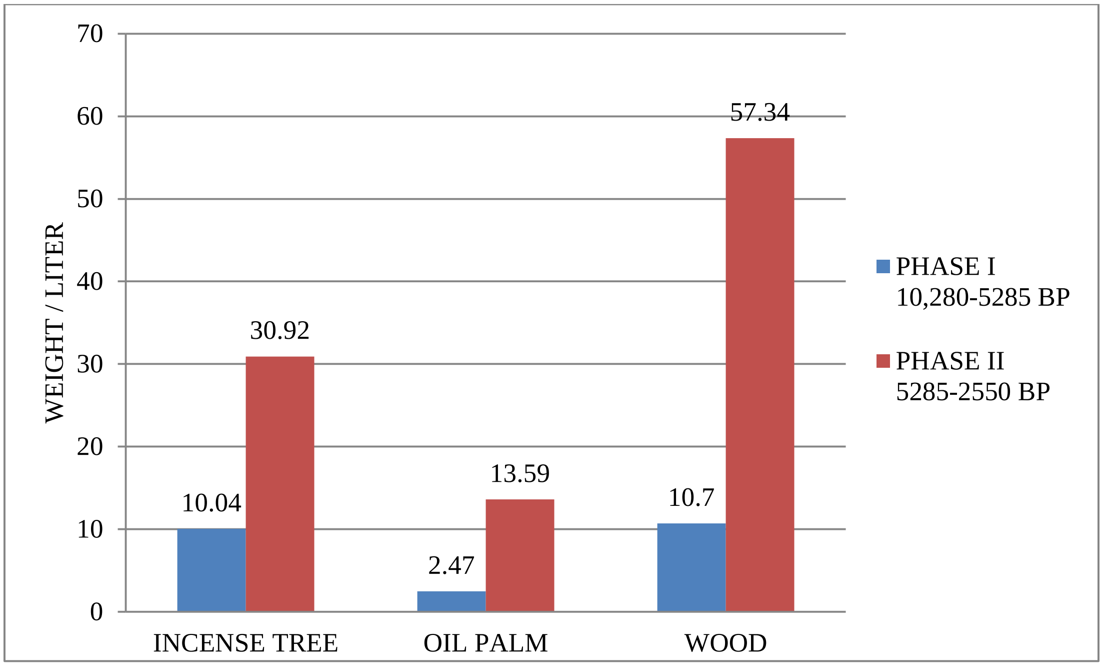


Figure 4.7 Wood and Tree-Fruit Density Ratios: Phase I and II



The horizontal distribution of charred plant remains amongst the units is similar to Phase I. The highest concentrations of macrobotanical remains are again found in Unit 7, near the edge of the shelter. A total of 43% of the wood, 38% of incense tree, and 90% of oil palm in Phase II were recovered from Unit 7 contexts alone.

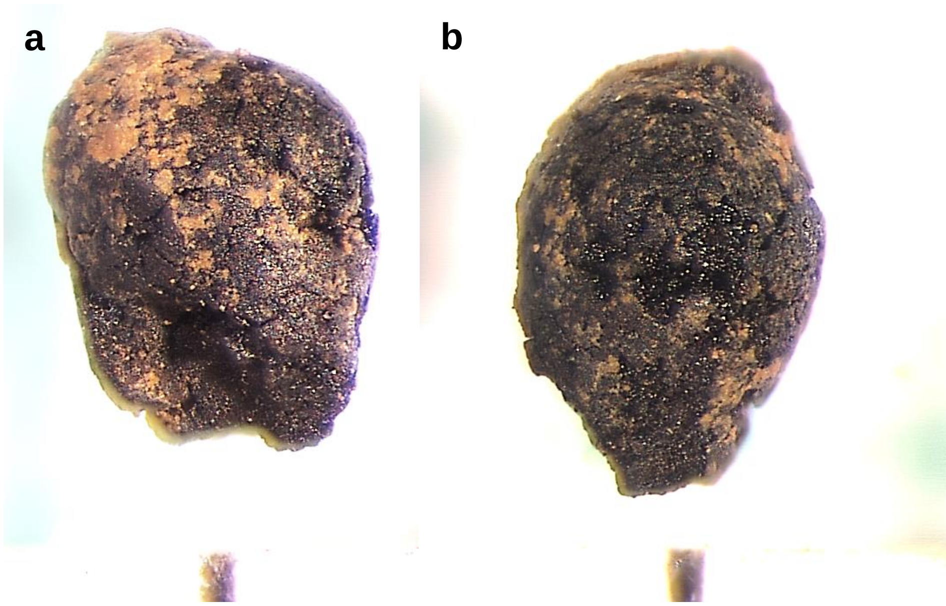
4.2.2.3 Domesticated Seeds

Table 4.5 Phase II: Domesticated Seeds

Domesticated Seeds						
	Unit	*Pennisetum glaucum*	*Pennisetum cf. glaucum*	*Vigna unguiculata*	*Vigna cf. unguiculata*	**Total Seeds**
Phase II 5285-2550BP	1	2	1			**3**
	2			1		**1**
	3					
	4					
	5	1				**1**
	6				1	**1**
	7					
	8					
	Total	**3**	**1**	**1**	**1**	**6**

A total of three grains of pearl millet, and one grain of probable pearl millet, designated *Pennisetum cf. glaucum*, were found in Unit 5 Horizon 3 (5285 ± 40 to 2550 ± 30 BP), and in Unit 1 Horizon 7 (pre 3490 ± 35 BP), although the latter may be intrusive from Horizon 8 (Table 4.5). Identifications of the Bosumpra pearl millet grains were based predominantly on the thickness-to-breadth measurements and the shape of the caryopsis (grain) (Figure 4.9). Grain measurements range 0.9-1.2 mm thickness and 1.1-1.4 mm breadth. While these are generally on the low end of modern pearl millet measurements (Brunken 1977:169), they fall within the range reported for other archaeological domesticated pearl millet (D’Andrea et al. 2001; Manning et al. 2011; Zach and Klee 2003).

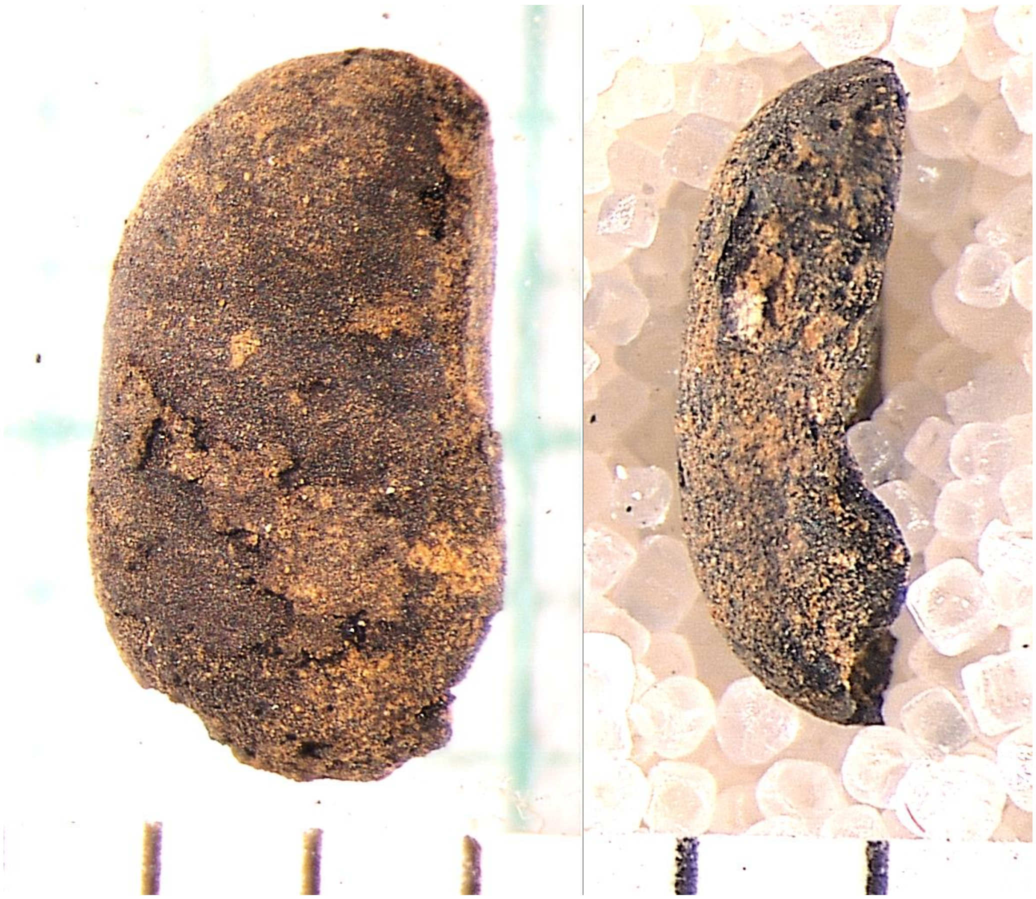
Figure 4.8 **Pennisetum glaucum *caryopsis a) dorsal view; b) lateral view (image by author)***



Previous archaeobotanical studies of archaeological pearl millet suggest that the most reliable way to distinguish between wild and domesticated forms are measurements of the apical thickness and the obovate or 'club' shape of the caryopsis, rather than on the overall size of the grain (D'Andrea et al. 2001; Klee et al., 2004; Neumann et al. 1996; Zach and Klee 2003). Studies of archaeological grains indicate that the first morphological changes in domesticated pearl millet were likely in the development of non-shattering form and in the shape of the grain, with size increasing only occurring later (D'Andrea et al. 2001; Zach and Klee 2003). Even today, the different landraces of domesticated pearl millet remain highly variable in grain size (Brunken 1977).

In addition to pearl millet, one fragmentary specimen of cowpea, and two fragments of probable (*cf*.) cowpea were identified in Phase II in Unit 6: Horizon 6 pre 2425 ± 35 BP, and in Unit 2: Horizon 8: 3490 ± 35 BP to 2550 ± 30 BP (Table 4.5). There are no complete specimens, which made obtaining metric data difficult; however length, 3.6-4.7 mm, and breadth, 2.4-2.7 mm, were able to be measured on all three specimens (Figure 4.10). While these measurements are generally smaller than ranges reported for the Kintampo B-site specimens (D'Andrea et al. 2007: 690) the Bosumpra specimens do fall within the range of specimens reported by Kahlheber from Burkina Faso (2004). Other morphological indicators of domestication (D'Andrea et al. 2007: 689; Kahlheber 2004) included the asymmetric outline and ovate cross-section of the cotyledons.

Figure 4.9* Vigna unguiculata *cotyledon (Photo by author)



4.2.2.3 Wild Edible and Weedy Seeds

Phase II samples had the highest recovery rate of seeds per liter soil processed for all phases (Table 4.6). *Bergia capensis* was again the most commonly recovered seed, although there was a slight increase in the abundance of some species (i.e., Poaceae and *Z. pentandra*) that might indicate open or disturbed environments.

Table 4.6 Phase II: Wild Edible and Weedy Seeds.

Wild Seeds											
	Unit	*Bergia cf. capensis*	*Zaleya cf.pentadnra*	Brassicaceae	Fabaceae	Poaceae	Ranunculaceae	Solanaceae	Unknown	Unidentifiable	**Total Seeds**
Phase II 5285-2550BP	1	114	1		3	3	1			12	**134**
	2	580	2		1	1	4		2	56	**646**
	3		3								**3**
	4	30			1		2			4	**37**
	5	123	1			1	8	1		8	**142**
	6	246		1			3		1	11	**262**
	7	252				1	4			1	**258**
	8	46									**46**
	Total	**1391**	**7**	**1**	**5**	**6**	**22**	**1**	**3**	**92**	**1528**

4.2.3 Phase III: Later Holocene Post 2550 BP

A total of 41 archaeobotanical samples, representing 460 l of processed soil were analyzed from Phase III from contexts which date post 2550 BP. Samples in Phase III contain on average 1.55 g of macrobotanical remains per liter soil, and have the lowest concentration of seeds, averaging only 0.85 seeds recovered per liter of processed soil.

4.2.3.1 Tree Fruits and Wood Charcoal

Wood charcoal was the most abundant plant macroremain, making up 79% of the total Phase III assemblage by weight (Figure 4.12). The increase in wood charcoal density, which doubles from Phase II to Phase III, is mirrored by a similar increase in oil palm density, and the highest density of oil palm is in Phase III samples (Figure 4.13). Between incense tree and oil palm there is a noticeable change in terms of both density and ubiquity between Phase II and Phase III samples (Figure 4.12). For the first time, oil palm replaces incense tree as the dominant tree fruit, present in 83% of the Phase III samples and making up 15% of the total

Phase III assemblage by weight. In contrast, incense tree is present in only 44% of samples, making up only 6% of the Phase III assemblage.

Figure 4.10 Percentage presence of charred plant materials in Phase II

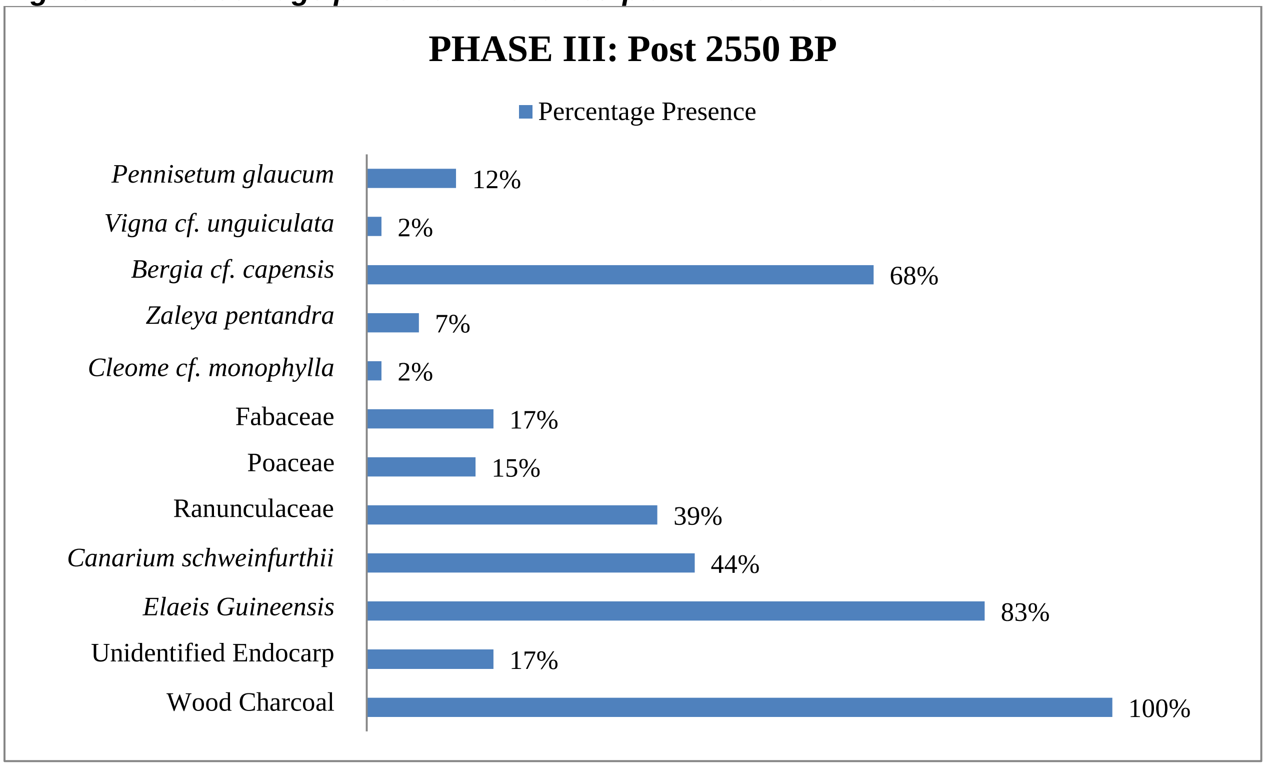
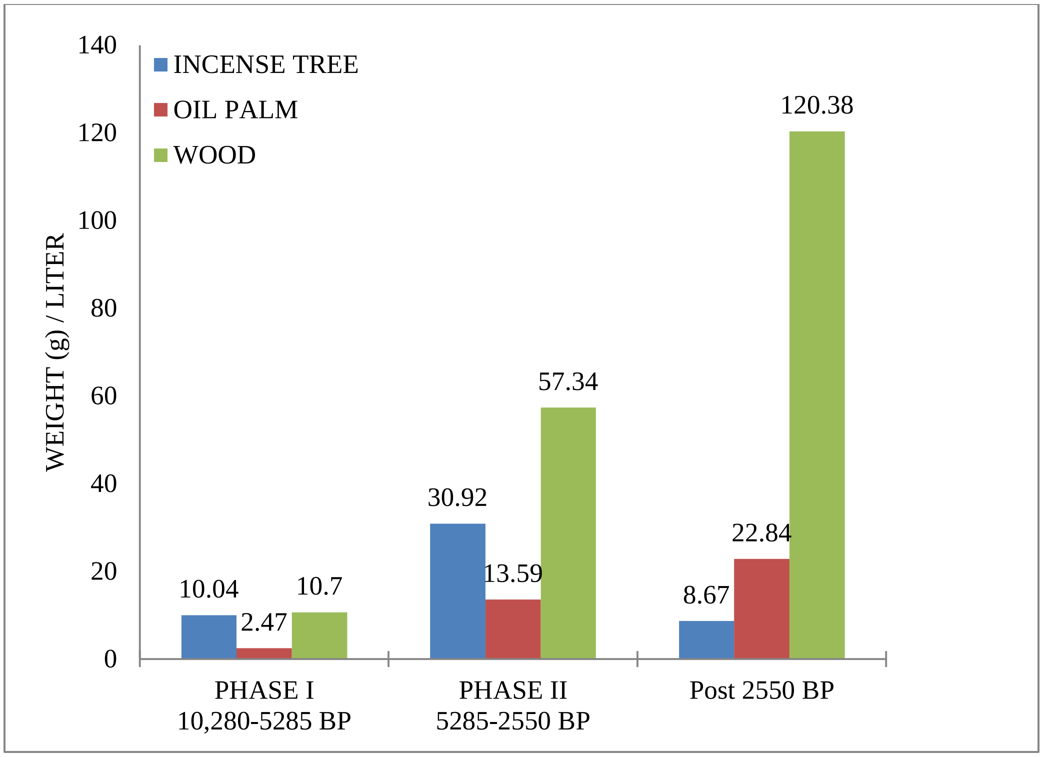


Figure 4.11 Wood and Tree-Fruit Density Ratios: All Phases



Overall, changes in the density of incense tree and oil palm support the observation made by Smith (1975) about the gradual replacement of incense tree with oil palm at Bosumpra (Figure 4.14). However, the results of this analysis do show that both taxa were used by the people occupying the shelter throughout the Holocene.

The horizontal distribution of macrobotanical remains in Phase III differs from Phase I and II. In contrast with earlier phases, wood charcoal and tree fruit remains in Phase III are far more evenly distributed across all excavated units. While in earlier levels remains tend to concentrate in Unit 7, in Phase III wood charcoal was concentrated in Units 2, 3, and 8, with the highest concentrations of seeds also found in Unit 2. Remains of oil palm were fairly abundant in most units, although they were slightly more concentrated in Unit 8 (30%). The greatest concentration of incense tree (48%) was recovered from Unit 6.

4.2.3.2 Domesticated Seeds

In Phase III, one grain of domesticated pearl millet 1.5 to 1.7 mm (thickness to breadth), and six grains of probable pearl millet 0.7-0.9 to 0.8-1.5 mm were recovered from Units 1, 2, 3, 4, and 7 which all date post 2550 BP. One seed of probable cowpea was also recovered from Unit 2 with a length 4.6 mm and breadth of 2.6 mm.

Table 4.7 Phase III: Domesticated seeds

Domesticated Seeds						
	Unit	*Pennisetum glaucum*	*Pennisetum cf. glaucum*	*Vigna unguiculata*	*Vigna cf. unguiculata*	**Total Seeds**
Phase II 5285-2550BP	1		1			**1**
	2		2		1	**3**
	3		1			**1**
	4		1			**1**
	5					
	6					
	7	1				**1**
	8					
	Total	**1**	**5**		**1**	**7**

4.2.3.3 Wild Edible and Weedy Seeds

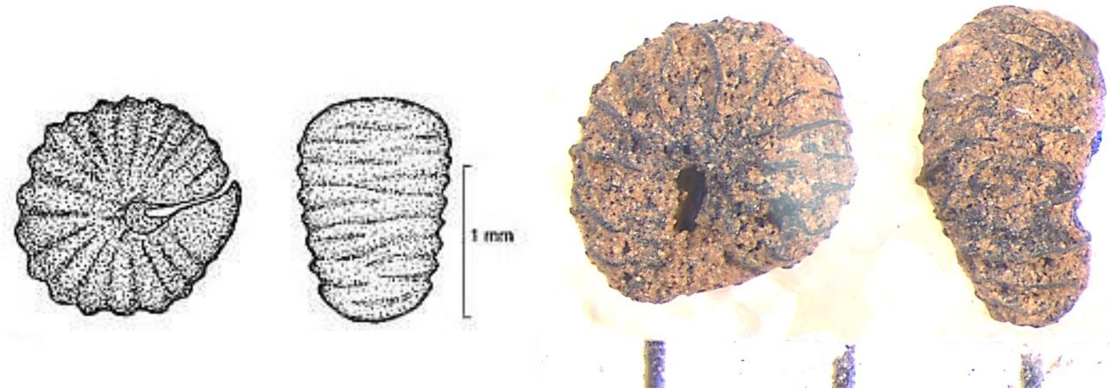
Table 4.8 Phase III: Wild edible and weedy seeds

Wild Seeds										
	Unit	*Bergia cf. capensis*	*Cleome cf. monophylla*	*Zaleya cf.pentadnra*	Fabaceae	Poaceae	Ranunculaceae	Unknown	Unidentifiable	**Total Seeds**
Phase II 5285-2550BP	1	1		1	1	1	2		17	**23**
	2	61	1	1	8	4	30	1	86	**192**
	3	40					2		6	**48**
	4	16		1			1		3	**21**
	5	8				2				**10**
	6	22			1		4		11	**38**
	7	13			1		2		3	**19**
	8	20			1	1	5		5	**32**
	Total	**181**	**1**	**3**	**12**	**8**	**46**	**1**	**131**	**383**

Cleome cf. monophylla

One probable seed of *Cleome monophylla L*. was found in a Phase III sample (Table 4.8). *Cleome monophylla* in Cleomaceae is an annual herb, commonly found in a wide range of disturbed contexts including grasslands, bushlands and deciduous woodlands in tropical and subtropical Africa (AFPD 2008; Burkill 1985: 329) (Figure 4.15). The fruits and particularly the young leaves of *C. monophylla* are a rich source of vitamin C, and are eaten as a vegetable or used in sauces as a seasoning. The seeds are also sometimes processed into a vegetable oil (Jansen 2004). The fruits and seeds are used as medicines for treating headaches, sores and swelling, and the roots are chewed as a cough suppressant (Jansen 2004; Burkill 1985: 329).

Figure 4.12 **Cleome monophylla** ***seed a) modified from IDAO 2010; b) photo by author***



4.3. Wood Charcoal Identification at Bosumpra

The analysis of wood charcoal from Bosumpra was completed as a pilot study where a small number of samples and fragments were examined. Although the vegetation of the Guinea-Congolian forests is less diverse than tropical forests elsewhere, the Guineo-Congolian rain forest is floristically very rich, with up to 200 species per 0.6 hectares (White 1983:71). Given the low number of analyzed fragments, no samples or phases were sampled to redundancy. This means that the discussion of these results is tentative, and that additional, more extensive analysis is necessary to understand the complex history of forest growth and change in the region of the Bosumpra rockshelter throughout the Holocene.

As for many herbaceous taxa in West Africa, publications and suitable reference materials for woody taxa in the tropical forest are limited. This is a problem particularly for trees which today are not considered to be economically important. During analysis, even when charred wood remains were able to be identified to family level, it was frequently not possible to examine or rule out many genera or species, as they were not available in comparative collections, published reports, or in online databases of wood anatomy.

Data from this study of wood charcoal at Bosumpra do provide some information about the local vegetation in each phase. Although approximately 32% of the total analyzed wood is indeterminate (unable to be identified to family level) the remaining 68% of identified taxa are characteristic of Guineo-Congolian forest taxa. In addition, identified taxa most often belong to the mixed semi-evergreen rain forest type, with even a few taxa present that today are common only in this type of forest west of the Dahomey Gap (White 1983: 77).

Most of the identified wood belongs to the Fabaceae (36% of the total assemblage) and Rubiaceae (9%) (Table 4.9). Today, many large trees in the Fabaceae subfamilies Caesalpinioideae and Mimosoideae are considered characteristic of Guineo-Congolian forest in Ghana (White 1983:74). A total of 27% of the assemblage from Bosumpra belong to taxa of Caesalpinioideae alone, and these are the dominant wood type present in every phase.

Other families in the Bosumpra assemblage that are characteristic Guineo-Congolian forest taxa include large-tree species in Chrysobalanceae and Meliaceae. Characteristic smaller woody plants were represented by species in the Annonaceae, Ebenaceae, Euphorbiaceae, and Rubiaceae families (Table 4.9). Two more unusual endemic Guineo-Congolian genera, *Aubrevillea* and *Calpocalyx*, were also identified. Large trees characteristic of the mixed moist semi-evergreen forest type west of the Dahomey gap, are represented by *Entandrophragma* sp. and *Parinari* sp. (White 1983: 77)

Table 4.9 Identified Wood Charcoal Fragments from Bosumpra

Wood Taxa (order of prevalence)	**Total Count**	**% of assemblage**
FABACEAE: Caesalpinioideae/Mimosoidea	43	36%
Indeterminate	38	32%
RUBIACEAE	11	9%
COMBRETACEAE-*Pteleopsis*	4	3%
MELASTOMATACEAE-*Memecylon/Dichaetanthea*	4	3%
PHYLLANTHACEAE-*Bridelia*	4	3%
ANNONACEAE-*Xylopia*	3	2%
RHIZOPHORACEAE-*Cassipourea*	3	2%
EBENACEAE-*Diospyros*	2	2%
EUPHORBIACEAE-*Macaranga*	2	2%
IXONANTHACEAE-*Phyllocosmus*	2	2%
MALVACEAE	2	2%
CHRYSOBALANCEAE-*Parinari*	1	1%
MELIACEAE- *Entandrophragma*	1	1%
TOTAL	**120**	

It should be noted that it is often difficult to distinguish between different types of Guineo-Congolian forest such as the coastal evergreen, mixed moist semi-evergreen, and mixed semi-evergreen types. While types of forest have a distinctive composition of endemic taxa, most are more widely dispersed and the changes between the different forest types is usually gradual (Keay 1959; Hall and Swaine 1976; White 1983). In addition, there are also many species which are considered characteristic of both transitional and savannah woodlands, as well as pioneer or secondary growth taxa in the Guineo-Congolian rain forest. This makes the task of assigning these taxa to specific forests types or growth stages difficult, even for larger studies (for a discussion on the current limitations of Guineo-Congolian wood reference materials see Höhn et al. 2008).

4.3.1 Phase I: Early to Mid-Holocene 10,280-5285 BP

In the Phase I samples, 27% of the identified wood by count belong to the Caesalpinioideae II type and 13% are in the Rubiaceae (Figure 4.10). While it was not possible to identify either the Caesalpinioideae or Rubiaceae wood types further, in Guineo-Congolian rain forests today these taxa are widespread and abundant. The shade-bearers *Xylopia* spp. (Annonaceae) are another common characteristic group in Guineo-Congolian forests (White 1983). Woodland savannah or more open, secondary Guineo-Congolian forest may be indicated by the presence of *Pteleopsis* spp. and *Bridelia* spp. Today *Pteleopsis cf. hylodendron/suberosa* is found in more open, savannah type forest or appears as a pioneer taxon in Guineo-Congolian forests (Hawthorne 1995; Poorter 2004). *Bridelia* spp. are pioneer taxa in Guineo-Congolian forests (Hawthorne 1995).

Wood charcoal from only two contexts was examined from Phase I, U7.H2.603 and U4.H5.550. For U7.H2.603 it was difficult to determine whether the context dated closer to *c*. 10,000 BP or 5,000 uncal. BP, however wood charcoals in U4.H5.550 are securely dated to older than 9990 uncal. BP ± 85. Again, one must be cautious with such a small sample, however it is interesting to note that a taxon that potentially indicates drier forest types or disturbed environments is present in this very early sample and that more characteristic Guineo-Congolian forest taxa were found in the Unit 7 sample (Table 4.10). The presence of drier-type vegetation *c.* 10,000 BP is consistent with the interpretations of Maley (1991) and Shanahan et al. (2006) which suggest there was a shift from an Early Holocene grass-dominated to forested vegetation *c*. 9500 BP, with fully forested conditions established once again at Lake Bosumtwi *c*. 9000 BP (Maley 1987, 1989; Talbot et al. 1984).

Table 4.10 Phase I Wood Charcoal (n=2) *(Bold taxa are characteristic of Guineo-Congolian rain forest, shaded taxa indicate possible open/savanna transition or secondary Guineo Congolian forest types)*

Wood Taxa (order of prevalence)	**Sample**	**Total Count**	**% of assemblage**	**Modern Uses***
Indeterminate	U4.550; U7.603	10	33%	
Caesalpinioideae II	U7.603	8	27%	
Rubiaceae II	U7.603	4	13%	
Pteleopsis cf. hylodendron/suberosa	U4.550	4	13%	M,T
Bridelia spp.	U4.550	2	7%	F,E,M,C,T,S
Xylopia spp.	U7.603	2	7%	F,E,M,C,T
TOTAL		**30**		

*After Irvine 1961: Abbreviations; F=firewood; E=edible (fruits and leaves); M=medicinal; O=oil; C=construction; T=technical processes (dyeing, tanning etc.); S=sacred

4.3.2 Phase II: Mid to Late Holocene 5285-2500 BP

Twice as many samples (n=4) were examined from Phase II, which may explain in part the higher diversity of wood charcoal types identified in these samples. However, Phase II samples are by far the richest in Fabaceae, Caesalpinioideae and Mimosoideae taxa, containing 63% of all identified Fabaceae taxa. Nine genera of Fabaceae were identified from Phase II samples, in contrast with the one type found in the other phases (Table 4.11).

The genus *Afzelia* (Caesalpinioideae) is the most commonly recovered taxon from the Phase II charcoal assemblage. The presence of *Afzelia* in these samples is difficult to interpret, as the anatomical features of both *A. africana* and *A. bella* are similar in many respects but they occur in different forest types (Hawthorne 1995). *Afzelia africana* is more commonly found in drier forests, appearing in both drier Guineo-Congolian forests, transition forest, and is scattered in savanna woodlands. In Ghana, *A. bella* however, is found more often in moist semi-deciduous forests. Additional Caesalpinioideae include *Guibourtia* sp*.* and several Caesalpinioideae types that could not be identified to genus. *Guibourtia cf. ehie*, (although other species cannot be completely ruled out), is a shade tolerant taxon common in upland evergreen forests in Ghana (Hall and Swaine 1981; Poorter 2004:419).

The Mimosoideae genera *Calpocalyx* and *Newtonia* are both common shade-bearer understory trees of wet and moist evergreen forests, especially in areas with acidic soils (Hall and Swaine 1981; Hawthorne 1995; Poorter 2004:158). *Aubrevillea cf. platycarpa* was also identified in the Phase II assemblage and is considered an endemic Guineo-Congolian taxon, especially in semi-deciduous forests (Hall and Swaine 1981; Hawthorne 1995; White 1983). Additional endemic Guineo-Congolian taxa include *Diospyros* spp. (Ebenaceae), a common shade-bearer taxon , and *Phyllocosmus cf. africanus* (Ixonthaceae) a common shade-bearer in moist semi-deciduous forests in Ghana (Hawthorne 1995).

The Phase II samples U8.622 and H3 U6.57 lie just above the spit dated to 5285 BP, while U7.582 and U8.616 are both from contexts closer to 2550 BP. Overall, most of the identifiable Phase II assemblage consists of characteristic Guineo-Congolian moist semi-deciduous forest types, although *Afzelia* and *Bridelia* may indicate a degree of drier or disturbed forest types.

Table 4.11 Phase II Wood Charcoal (n=4) *(Bold taxa are characteristic of Guineo-Congolian rain forest, shaded taxa indicate possible open/savanna transition or secondary Guineo Congolian forest types)*

Wood Taxa (order of prevalence)	**Samples**	**Total Count**	**% of assemblage**	**Modern Uses***
Indeterminate	U8.622; U6.582; U7.571; U8.616	23	38%	
Caesalpinioideae cf. *Afzelia* *africana*/***bella***	U7.582; U8.616	6	10%	F,E.M,O,C, T
Caesalpinioideae I	U7.582	4	7%	
Mimosoideae cf. *Newtonia duparquetiana/ Calpocalyx brevibracteatus*	U6.571	4	7%	E,M,C,T
Rubiaceae II	U6.571	3	5%	
Fabaceae I	U6.571; U7.582	3	5%	
Caesalpinioideae II	U6.571; U7.582	3	5%	
Caesalpinioideae cf. *Guibourtia spp.*	U8.622	3	5%	E,M,C,T,S
*Bridelia cf. grandis/**micrantha***	U7.571	2	3%	F,E,M,C,T, S
Malvaceae	U7.582	2	3%	
Mimosoideae cf. *Aubrevillea platycarpa*	U7.582	2	3%	M,T
Diospyros sp.	U7.582	2	3%	E,M,C,T
Mimosoideae I	U7.582	1	2%	
Fabaceae II	U7.582	1	2%	
Phyllocosmus cf. africanus	U6.571; U7.582	1	2%	F,E,M,C,T
TOTAL		**60**		

*After Irvine 1961: Abbreviations; F=firewood; E=edible (fruits and leaves); M=medicinal; O=oil; C=construction; T=technical processes (dyeing, tanning etc.); S=sacred

4.3.3 Phase III: Later Holocene Post 2550 BP

Phase III, while lower in Fabaceae taxa, has a rich and diverse assemblage of Guineo-Congolian wood types, including those present in samples from other phases: *Xylopia* spp., *Phyllocosmus cf. africanus*, and the ubiquitous Caesalpinioideae type II (Table 4.12). *Entandrophragma* spp. (Meliaceae) includes several species of Guineo-Congolian forests west of the Dahomey Gap (White 1983:77). *Entandrophragma cf. cylindricum* or *utile* are both large tree species common in upland moist forests in western forests (Hawthorne 1995; Poorter 2004: 412-413). Remains of *Cassipourea cf. congoensis* (although other genera cannot be ruled out) (Rhizophoraceae) is a common shade-bearer taxon in moist semi-deciduous Guineo-Congolian forests (Hawthorne 1995). Remains of *Parinari* spp. are interesting as they are more common to montane or upland forest types (Hawthorne 1995.)

Two possible genera of Melastomataceae**,** *Memecylon* and *Dichaetanthea*, are found in the Phase III samples. Several species of *Memecylon* are characteristic small trees or shrubs, commonly found in Ghana beside rivers and in the moist upland forests (Hall and Swaine 1981: Poorter 2004: 284). However *Dichaetanthera cf. africana* is a pioneer taxon that is found in open areas in evergreen Guineo-Congolian forests (Hawthorne 1995). Other pioneering taxa include *Macaranga* spp.(Euphorbiaceae), which are small pioneering taxa common in disturbed areas of Guineo-Congolian forest (Hawthorne 1995).

Table 4.12 Phase III Wood Charcoal (n=2) *(Bold taxa are characteristic of Guineo-Congolian rain forest, shaded taxa indicate possible open/savanna transition or secondary Guineo-Congolian forest types)*

	Wood Taxa (order of prevalence)	**Samples**	**Total Count**	**% of assemblage**	**Modern Uses***
PHASE III	Caesalpinioideae II	U8.597 U8.598	8	27%	
	Indeterminate	U8.598	5	17%	
	cf. *Memecylon spp.* / *Dichaetanthera spp.*	U8.597 U8.598	4	13%	M
	Rubiaceae I	U8.598	3	10%	
	Cassipourea cf. congoensis	U8.597	3	10%	
	Macaranga sp.	U8.597	2	7%	F, M, C, S
	Rubiaceae II	U8.598	1	3%	
	Entandrophragma cf. cylindricum/utile	U8.597	1	3%	F, M, C
	Phyllocosmus cf. africanus	U8.598	1	3%	F, E, M, C, T
	Parinari spp.	U8.597	1	3%	F, E, M, O,C, T
	Xylopia spp.	U8.597	1	3%	F, E, M, C, T
	TOTAL		**30**		

*After Irvine 1961: Abbreviations; F=firewood; E=edible (fruits and leaves); M=medicinal; O=oil; C=construction; T=technical processes (dyeing, tanning etc.); S=sacred

4.4 Summary

In Phase I, both incense tree and oil palm endocarp remains are present in the very earliest deposits at Bosumpra, although there are much greater densities of incense tree than oil palm. The presence of the semi-aquatic species *Bergia cf. capensis* and the very low quantity of Poaceae (grass) remains, suggest somewhat wet conditions were present in the early to mid- Holocene. Overall, although limited, the anthracological data seem to indicate that forests were present in this phase, although there may be some indications of more open or drier forest types *c*. 10,000 BP.

There is an increase in the densities of all types of macrobotanical material in Phase II. The highest densities of incense tree and seeds are found in these samples, although there is overall a more dramatic increase in the density of oil palm and wood charcoal. In addition to wild weedy and edible seeds, which are similar those from Phase I, domesticated grains of pearl millet and a few potential cowpeas appear at Bosumpra for the first time in Phase II. The wood charcoal identified from Phase II contains the greatest diversity of taxa, many of which today are considered characteristic of the Guineo-Congolian mixed-semi deciduous rain forest type.

When compared with the preceding phases, the macrobotanical assemblage in Phase III is noticeably different. While incense tree does not entirely disappear, it is displaced by oil palm as the dominant tree fruit taxon. The highest densities of oil palm and wood charcoal are found in Phase III, where there is an overall decrease in the density of seeds, although more grains of pearl millet and probable pearl millet were recovered. In this phase, identified wood charcoal remains continue to consist of largely Guineo-Congolian taxa.

5. Continuity and Change: Examining 10,000 Years of Plant Use at Bosumpra

5.1 Introduction

The central aim of this macrobotanical analysis was to assess continuity and change in the use of local tree-fruit species, local and non-local domesticates, and other wild plant resources for food, fuel, and other purposes over the more than 10,000 year occupations at Bosumpra rockshelter. In particular, I tested Smith's (1975) hypothesis about changing patterns in the use of incense tree and oil palm use at the shelter. The resulting density ratios from this study clearly indicate that both incense tree and oil palm were longstanding and important resources for inhabitants at Bosumpra throughout the LSA. The data both confirm and refine Smith's (1975) original observations about the relative changes in incense tree and oil palm use over time, and provide direct evidence for the great antiquity and continuity in the use of these resources in tropical forest habitats in Ghana.

As this study also aimed to provide a better understanding about the nature and timing of the early use of domesticated plants in West African tropical forest environments, the charred remains of pearl millet and cowpea from this archaeobotanical study document the appearance of these domesticates in the southern rainforest regions of Ghana in the terminal LSA. Altogether, the patterns of plant use at Bosumpra shed light on LSA hunter-gatherer subsistence practices in these forested environments. This permits us to begin exploring how the relationships of different LSA populations with oil palm and other plant resources changed in the terminal LSA as hunter-gatherer populations in the forest began to interact with early food-producing populations in Ghana.

In this chapter, I situate the results of this study of plant use at Bosumpra into the broader sub-Saharan West African archaeological framework, comparing and contrasting the available archaeobotanical data to look at how relationships between hunter-gatherer populations and forest resources adjusted or remained constant as part of larger socio-political, climatic, and vegetation changes in the LSA. I begin with a discussion about the importance of tree fruit resources in forest habitats in the Early Holocene, focusing on what the nature of the early relationships between hunter gatherer populations and incense tree and oil palm. I then discuss changes evident in plant use and procurement at Bosumpra throughout the Middle and later Holocene. This is followed by a brief review of the archaeobotanical data from Kintampo sites and comparison of the evidence for oil palm use, management, and production between these populations in the terminal LSA. Finally, I discuss the appearance of plant domesticates at Bosumpra, where I explore what the presence of pearl millet and cowpea might indicate in terms of changing subsistence strategies and regional interaction.

5.2 Early Holocene Tree Fruit Use: Insights from Bosumpra

5.2.1. The Antiquity of Oil Palm Use in Ghana

Both oil palm and incense tree are frequently reported macrobotanical remains from LSA sites in West African forested regions. While the earliest direct evidence for the intensive processing and possible practice of oil palm arboriculture comes from several Kintampo sites in central Ghana c. 3600-3200 BP (D'Andrea et al. 2006; Logan and D'Andrea 2012), the southern areas of rainforest in Ghana have long been considered promising places to find earlier evidence for oil palm use and possibly cultivation (Andah 1993: 250; Posnansky 1984; Sowunmi 1985, 1999, 2002; Stahl 1993: 263; Logan and D'Andrea 2012).

Oil palm and incense tree are unable to regenerate in the full shade of the primary forest canopy, meaning that their growth is limited to recent forest gaps, riverine forest areas, and in bands of savanna-forest transition (Hall et al., 1978: 259; Hall and Swaine 1976). Human activities related to the collection and consumption of oil palm would have played an important role in encouraging the growth and spread of this tree, because it such has high light and water requirements and yet it is found in closed forest environments (Andah 1993; D'Andrea et al. 2006; Harlan et al. 1976; Harris 1976; Logan and D'Andrea 2006; Sowunmi 2002; Stahl 1985).

Unfortunately our ability to understand the timing and the nature of early oil palm use and management has been hindered by the limited collection or quantitative analysis of archaeobotanical materials, and because wild and cultivated forms of oil palm have, until relatively recently, been morphologically indistinguishable. As traditional models of agriculture are based largely on recognizable morphological changes as indicators of human selection and management (i.e., Smith 2001), characterizing the relationship of hunter-gatherer populations and early food producers with this widespread and intensely used resource has proven problematic and at times controversial (Casey 2005; D'Andrea et al. 2006; Logan and D'Andrea 2012; Maley and Chepstow-Lusty 2001; Marshall and Wiessbrod 2011; Sowunmi 1999, 2002).

Until recently, Smith's 1975 published reports of oil palm at Bosumpra were considered to be the earliest evidence of oil palm use in Ghana. The results from this analysis provide the first direct evidence for the great antiquity and continuity of oil palm use occurring from at least 8410 uncal. BP. The continuous presence and gradually increasing density of oil palm at Bosumpra, even from periods when to our current knowledge the forests were fully established, raise some interesting questions about the degree to which local landscapes may have been modified and managed by populations in tropical forest environments over the LSA. Although difficult to demonstrate, it is possible that human activities in the forest landscapes surrounding Bosumpra could have increased the distribution of this important food-source through the dispersal of seeds after consumption. With even minimal effort, it would have been possible to enhance the suitable environments and encourage oil palm and incense tree growth by selecting other taxa for fuel and reducing canopy competition.

5.2.2. Evidence for LSA Incense Tree Use

In the Early to mid-Holocene occupation layers at Bosumpra, incense tree endocarp is the most commonly occurring plant food remain, present in 77-78% of the samples and dominating the macro-botanical assemblage in terms of density. As incense tree fruits only ripen in the wet season, the high densities of incense tree at Bosumpra provides some evidence for the timing of occupation at the shelter. Following the studies of Bonzani (1997) and Lepofsky and Lyon (2003), the high ubiquity of incense tree, along with the overall very low plant diversity in the assemblage, suggests that the gathering and processing of incense tree fruits was an important scheduled activity at Bosumpra in addition to stone tool manufacture and maintenance.

While incense tree is considered less economically important today, a study of leaf fossils from shoreline sediments of Lake Bosumtwi suggests that incense tree may have been an important resource for the inhabitants of the local forest habitats as early as 10,000-9880 uncal. BP (Hall et al.1978). Fossils of incense tree leaves were the most abundant of all the identified tree and shrub species recovered from these sediments (Hall et al.1978). As incense tree is rare today in mature forests and unable to regenerate under the shade of the closed canopy, the high percentage of incense tree suggests the presence of more open forest conditions, perhaps due to natural disturbances (i.e., landslides or lowering lake levels) (Hall et al. 1978). The presence of drier-type vegetation at 10,000 BP would be consistent with the interpretations of Lake Bosumtwi sediments by Maley (1991) and Shanahan et al. (2006)

indicating a shift from a grass-dominated to forested vegetation around 9500 BP, with fully forested conditions established once again by 9000 BP (Maley 1987, 1989; Talbot et al. 1984). However, as incense tree is rare even in secondary forests in Ghana today, the surprisingly high percentage of incense tree in the Early Holocene samples may also signify that human activities encouraged this species (Hall et al. 1978).

Although there has been relatively limited excavation or botanical analysis of early Holocene forest sites, incense tree appears to have been a broadly important resource for LSA populations in forested environments (Table 5.1). Incense tree recovered the site of Shum Laka in Cameroon indicates a long and intense use of incense tree fruits, beginning around 7000 BP (Lavachery 2001: 226). Furthermore at the Ituri sites in the Democratic Republic of Congo, where modern foraging populations continue to use both incense tree and oil palm, there is evidence for the use of incense tree as early as 10,015 BP (Itchikawa 1992; Mercader 2003: 101, 106).

Table 5.1 Archaeological Reports of Incense Tree

COUNTRY	SITE	ASSOCIATED DATES (BP)	DIRECTLY DATED INCENSE TREE (BP)	SOURCE
Ghana	Bosumpra	10,280-Post 2550	6300	Watson (in preparation) Ch. 4; Table 4.3
	K6	6100-3495		Stahl 1985a
	B4C; B5C; B6B	3470-3380		D'Andrea et al. 2006
Cameroon	Shum Laka	7140-6070		Lavachery 2001
	Bwambé-Sommet; Akonétye; Minyin	2400-2200; 1950-1600		Neumann et al. 2012
Democratic Republic of Congo	IBSW; L; MTNW	18,800-715	825 2970 10,015	Mercader 2003

In Ghana, archaeobotanical remains of incense tree recovered from LSA Kintampo and Punpun sites do appear to be more heavily utilized prior to periods of intensive oil palm production by the Kintampo, where incense tree made up only a fraction of macrobotanical assemblages (D'Andrea et al. 2006; Casey 2005: 234; Logan and D'Andrea 2012; Rhatz and Flight 1974, 1976; Stahl 1985; Watson 2005a). The patterns of incense tree use at Bosumpra, specifically the intense early use and decline in the later Holocene, may represent a broader shift in tree fruit use and preference amongst forest dwelling populations, with oil palm ultimately becoming the more favored resource.

5.3 Changing Patterns of Plant Use and Procurement

5.3.1 Tree-Fruit Use at Bosumpra during the LSA

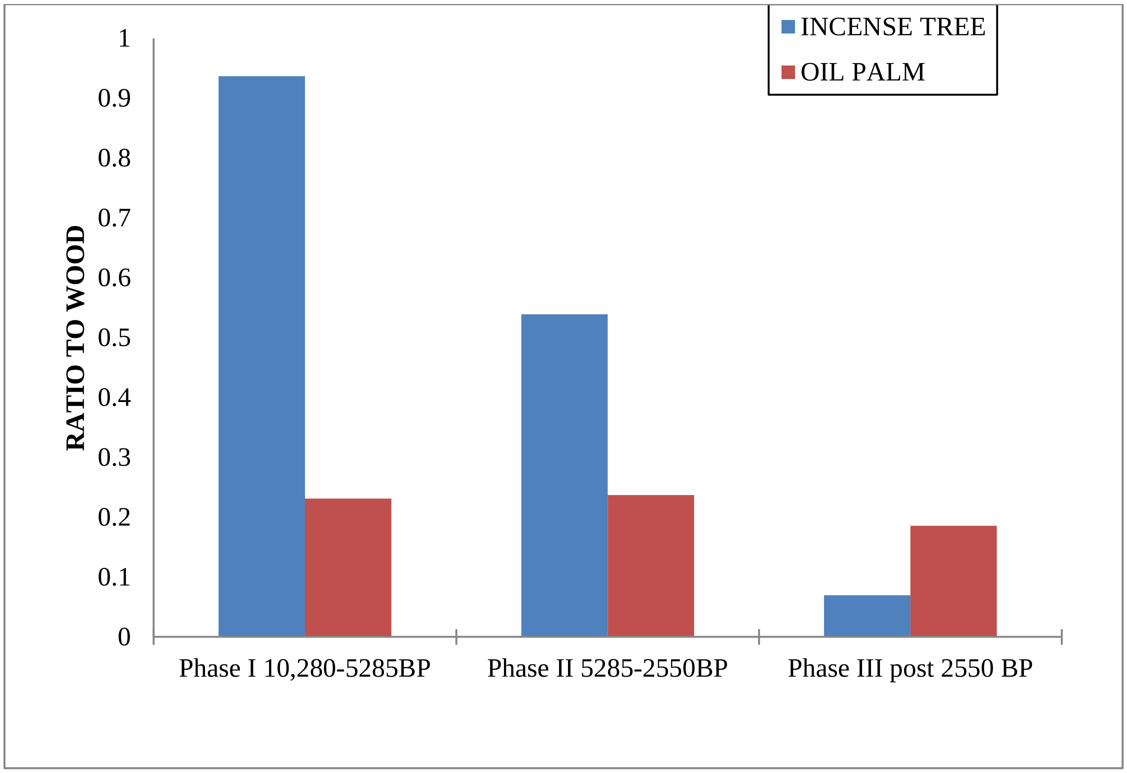
Looking at the changes in density from the Early to mid-Holocene, incense tree densities increase, tripling from earlier periods. However the changes in oil palm and wood charcoal densities are even more dramatic, increasing by five times over the same period. As I have taken the presence of wood charcoal to most likely reflect daily burning activities (e.g., heating, food production, cooking, trash disposal), increases in the density of wood charcoal might indicate (among other possibilities) more frequent or longer visits to the shelter, or that the shelter was occupied by larger groups. Whatever the cause, this increase in tree-fruit density is not altogether surprising, as with increased burning activity there would be a greater chance of exposure of tree-fruit remains to fire, whether by chance or from cooking, oil processing, or from use of the endocarp by-products as fuel, all of which would result in higher densities of both tree fruits.

However, given this expectation, the changes in density in samples dating post 2550 BP are particularly interesting, as the density of wood charcoal doubles again but the density and ratio of tree fruit taxa change dramatically. The greatest density of oil palm dates to this period, with oil palm present in over 80% of samples. This suggests that more intensive collection and use of oil palm occurred at Bosumpra post-2550 BP, perhaps related to climatic changes and the introduction of iron metallurgy. Conversely, measures of incense tree density and ubiquity drop sharply, which may indicate that there was a change in the perceived importance of incense tree as a resource in the later Holocene. Of course the decrease in density may also reflect some changes in the timing of occupations and/or the associated activities carried out at the shelter. It seems unlikely that the decrease in incense tree density documented at Bosumpra reflects climatic change, as records from lake Bosumtwi indicate that 2660-1000 cal. BP local conditions were increasingly arid (Shanahan et al. 2009: 378), a change which would have expanded the secondary forest habitats naturally occupied by incense tree.

It is more difficult to evaluate the meaning of the increasing density of oil palm at the shelter. Using the density of wood charcoal as an index of the level of burning, some interesting patterns appear when the densities of incense tree and oil palm are compared to charcoal

(Figure 5.1). While the decline of incense tree is very apparent, the ratio between oil palm and wood remains fairly constant over all periods, suggesting the longstanding and likely increasing importance of obtaining and using this resource in the LSA.

Figure 5.1 Density of Incense Tree and Oil Palm to Wood Charoal



5.3.2 Evidence for Oil Palm Use and Management in the Terminal LSA

In recent years, evidence has been presented for the increasing production and possibly for the practice of oil palm arboriculture in the terminal LSA (D'Andrea et al. 2006; Logan and D'Andrea 2012). However, as previously discussed finding evidence for oil palm arboriculture has proved difficult. Arguments for human cultivation of oil palm have been made based on significant spikes in oil palm pollen 3750 BP (Talbot et al. 1984: 190; Sowunmi 2002: 98) and 3200-2800 BP (Sowunmi 2002: 99). Sowunmi (2002: 101-103) has argued that the rise in oil palm pollen might be the result of human activity and the practice of slash and burn cultivation in these forest regions for the cultivation of oil palm or other crops. However, such arguments for human induced vegetation change remains controversial, as it is impossible to distinguish between human and natural agents in the pollen record in this case (D'Andrea et al. 2006). It is equally possible that natural, climatic factors led to vegetation change, the opening of the forest, and the increase in oil palm around 2800 BP (Maley and Chepstow-Lusty 2001;Salzman 2005).

While no remains of oil palm or other tree fruits were found at the Kintampo site of Birimi in northern Ghana (D'Andrea et al. 2001; D'Andrea and Casey 2002), the most direct evidence for the intensive production and management oil palm comes from Kintampo sites in central Ghana, where the intense processing of oil palm is indicated by high densities and heavy fragmentation of analyzed oil palm endocarp (D'Andrea et al. 2006). As the processing of oil palm today in Ghana involves fragmentation of the endocarp and the prolonged exposure of fruits to heat and boiling to purify the oil (D'Andrea et al. 2006; Irvine 1969; Zeven 1967, 1972), other likely archaeological correlates of processing and increasing oil palm production at Kintampo sites include hammer stone tools and the high densities of ceramics and oil palm.

While ceramics are present at Bosumpra in even some of the earliest contexts, and increase in density in Phase II, the numbers of ceramics at Bosumpra never reach those reported for the Kintampo B and K sites (Stahl 1985; Watson 2005a, 2010, in preparation). Furthermore, oil palm endocarp at Bosumpra also does not dominate the macro-botanical assemblage in the same way as at the B-sites, where wood charcoal made up only a small percentage of the macroremains relative to oil palm endocarp (D'Andrea et al. 2006). Although oil palm becomes the dominant food resource found at Bosumpra in later Holocene occupations, the differences in the density and fragmentation of oil palm macroremains, especially in relation to wood charcoal and incense tree, suggest some major differences perhaps in the significance, and certainly in the scale of production of palm oil by occupants at Bosumpra and by the Kintampo populations.

When reviewing the evidence from Bosumpra for the early use, and perhaps low-level management of oil palm and incense tree, it is worth considering that the contrast in the use of these resources by populations at Bosumpra and at the Kintampo sites may be indicators of underlying differences in hunter-gatherer and food-producer strategies in the terminal LSA. It appears that there was an intensive and nearly exclusive focus on oil palm use at the Kintampo B-sites, where Kintampo management of oil palm may reflect an early manifestation of later documented agroforestry practices, characterized by the integration of field and tree species cultivation, in medieval West Africa (i.e., D'Andrea et al. 2006; Logan and D'Andrea 2012; Kahlheber 1999).

At Bosumpra, while oil palm becomes increasingly dominant after 2550 BP, the continuous use and high densities of incense tree found at the shelter in Kintampo times may signal underlying differences in hunter-gatherer and food-producer relationships with these tree resources. Although preliminary, we begin to see on one hand, the importance of oil palm in the subsistence practices of early food-producers in Ghana, and that it grows to become the basis of agroforestry practices found in these regions even today (D'Andrea et al. 2006). In contrast, while incense tree appears to dominate terminal LSA subsistence at Bosumpra and was heavily utilised or possibly managed by foragers occupying the site, its use seems to become increasingly marginal following the terminal LSA, and it never becomes part of agroforestry systems developing later in the region.

5.3.3 Domesticated Plants at Bosumpra

The presence of domesticated pearl millet and cowpea remains at Bosumpra, similar to those found in savanna-forest Kintampo sites, provides a further point of comparison and discussion between these LSA populations in Ghana. The appearance of pearl millet in particular is surprising at Bosumpra, as modern landraces of pearl millet are adapted to dry conditions and do not tolerate water-logging and high atmospheric humidity. This makes the rain forest conditions present around Bosumpra particularly unfavorable for cultivation.

The wild progenitors of pearl millet are thought to have been in the southern fringes of the Sahara in West Africa (Brunken et al. 1977: 173; Burkill 1994: 315; Harlan 1971: 470-471), and recent studies suggest that one centre of pearl millet domestication is in southeast Mauritania c. 4500 cal. BP (Manning et al.: 2011). By c. 4,000 BP a second Sudanian center of diversity developed near lake Chad where late-maturing, more wet tolerant cultivars were grown (D'Andrea and Casey 2002; Kahlheber and Neumann 2007; Tostain 1992, 1998; Tostain and Marchais 1993).

Peal millet would have been a cereal crop especially suitable for dry seasonal conditions in the savanna and Sahel when other sources of carbohydrates were scarce. In sub-Saharan Africa, harvests of pearl millet are obtained in regions with a mean annual rainfall of 250-800 mm (Brunken 1977: 161). This low water requirement of pearl millet would have made it an appealing choice to seasonally-mobile pastoralist-collectors in the southern edges of the Sahara, who perhaps began the process of domestication (Manning et al. 2011). Once domesticated, it appears that pearl millet rapidly spread in West Africa and eastwards as well, reaching India by 3700 BP (Fuller 2003; Neumann 2005), and by the fourth millennium BP it is likely that these late-maturing forms of pearl millet were integrated into Kintampo subsistence practices.

The earliest evidence for pearl millet in Ghana, and its large-scale cultivation comes from the Kintampo site of Birimi , with grains dated to 3250-3130 cal. BP (D'Andrea et al. 2001: 343). Here the cultivation of pearl millet is thought to reflect a local response by Kintampo populations to increasing aridity and more pronounced seasonal climates, and it is interesting to note, that tree fruits of any kind so far do not appear to have been a part of Birimi subsistence practices (D'Andrea et al., 2001; D'Andrea and Casey 2002). Slightly later and further south, near the modern day edge of the favorable region for pearl millet cultivation, a few domesticated grains are also reported from Kintampo B-sites in central Ghana, where there again appear to be slightly different local Kintampo subsistence adaptations involving domesticated cowpea, oil palm, and in a limited way incense tree and hackberry (D'Andrea et al. 2006; Stahl 1985b). The appearance of pearl millet here may more likely reflect regional trade and exchange amongst Kintampo populations than large-scale local cultivation (D'Andrea et al. 2001).

At Bosumpra, the presence of a few grains of pearl millet by at least the mid third millennium BP seems to fit with this model of pearl millet dispersal suggested by Kintampo data (D'Andrea et al. 2001; D'Andrea and Casey 2002). While this makes the appearance of pearl millet somewhat less surprising, it raises questions about local environmental conditions and landscape use by forest populations, and in particular about changes in the nature of regional interaction and the relationships amongst hunter-gatherer groups and early food producers in Ghana in the terminal LSA.

Remains of legumes are often less likely to be preserved in archaeological contexts and are thus often under-represented in macrobotanical assemblages (Gasser and Adams 1981: 183-184). As such it has proven difficult to establish the timing, relative importance, and the context of cowpea domestication in the LSA. Many specimens of probable cowpea, *Vigna* cf. *unguiculata* were reported from the Kintampo excavations at K6 (Flight 1976: 217-218), as they were at the time deemed too small to be domesticated cowpea (Stahl 1985b: 141; 1994:76). However, recent archaeobotanical studies, have confirmed the early presence of domesticated cowpea dating to 3898-3475 cal. BP (D'Andrea et al. 2007: 689) from the Kintampo B-sites in central Ghana. These are the earliest yet recorded cowpeas, predating those dated from India 1700-1300 cal. BC (Fuller 2003: 242-243). Thus, although this is based on a single dated domesticated cowpea, it suggests the West African origin of domesticated cowpea in the early fourth millennium BP, and it also suggests that, like pearl millet, cowpea spread rapidly once it was domesticated (D'Andrea et al. 2007).

At Bosumpra, the remains of cowpea are again similar to those reported from the Kintampo B-sites and also likely from K6. While conditions around Bosumpra would be more favorable for cowpea cultivation than pearl millet, the appearance of cowpea at the shelter, like pearl millet, may again reflect trade and exchange rather than local cultivation.

Climate changes are indicated around 3000 BP at Lake Bosumtwi, where drops in lake level indicate the onset of drier and more seasonal modern conditions (Russell 2003; Shanahan et al. 2006; Talbot et al. 1984). At present however, it is extremely difficult to determine how these changes affected local vegetation or if some degree of local pearl millet cultivation would have been possible, as has been suggested for pearl millet finds in the rainforests of Cameroon in slightly later periods (Kahlheber et al. 2009; Neumann et al. 2012). Given the elevation and conditions present around Bosumpra today, and the limited macrobotanical and wood charcoal findings from this study which seems to show consistently moist conditions, the occurrence of pearl millet at Bosumpra may more likely indicate the early trade and exchange of food resources between forest hunter-gatherer groups and food-producers in the terminal LSA.

When one considers models based on ethnographic accounts of food-producer and forest hunter-gatherer interactions and exchange relationships (e.g., Spielmann and Eder 1994), the importance of carbohydrates obtained from food producers in hunter-gatherer diets is often stressed, and it is possible these became important resources for forest-dwelling populations and were obtained perhaps in exchange for wild forest resources. But, it is also true that in these forested regions where pearl millet cultivation may not have been very successful, knowledge about local forest resources, and especially about nutrient and fat rich resources such as incense tree and oil palm would have been of considerable value.

5.4 Summary

Although this analysis of plant materials from Bosumpra provides data from only a single site, the findings resonate with more widespread work on early Holocene subsistence practices, the importance of incense tree to forest inhabitants, and the regional spread of West African plant domesticates. While more work is necessary to understand and characterize the relationships LSA populations had with oil palm in Ghana, evidence from Bosumpra confirms the great antiquity of its use and provides some insight into the broader spectrum of collection and processing strategies in Kintampo times. Finally, the study of these charred plant materials from Bosumpra mark the appearance of domesticated plants in the rain forested regions of Ghana in the LSA, a subtle indication of what may be the earliest evidence of interaction and exchange between hunter-gatherers and food producers in these forest regions.

6. Conclusion

The aim of this thesis research was to begin examining the relationships between LSA West African populations living in the sub-Sahelian tropical forest habitats and the plant resources that made up their local landscape. The analysis of the macrobotanical materials from the Bosumpra rockshelter provides a picture of continuity and change in the gathering of local plant resources, and documents the arrival of more exotic domesticates in the later Holocene, an especially dynamic period of socio-political and environmental change. Although far more archaeological and archaeobotanical research is necessary to understand the nature of LSA population interactions with their surrounding forest landscapes and plant resources, this thesis provides the first full archaeobotanical analysis for pre-Kintampo LSA populations in the forested region of southern Ghana.

This research documents the use and perhaps preliminary management relationships with oleaginous woody taxa, incense tree and oil palm, in the forests of Ghana, for which there has long been speculation, but little direct evidence. At Bosumpra, it is clear that both species were used, and indeed, the collection and processing of these taxa, especially incense tree, most likely were one of the important activities perhaps determining when the shelter was used. Although during the Holocene oil palm can be seen to displace incense tree as the dominant oleaginous tree-fruit resource used at the shelter, the importance of both these tree-fruit resources clearly spanned from the early Holocene, continuing well past the advent of food-production in Ghana.

While only representative of one site, this analysis contributes to regional understanding about the nature and timing of the use of these plant resources. To understand the geographic extent and level of integration and interaction amongst Early Holocene hunter-gatherer groups occupying these forested habitats, exploring the continuity and similarities or variations in subsistence practices is a crucial part of archaeological investigations and comparisons based on other archaeological data. Building upon the preexisting, though limited, data, this research helps establish the foundation for further investigations into the networks of people, plants, and subsistence practices in West and Central tropical forested habitats over the Holocene.

More broadly, this study contributes to discussions of early plant domestication and food-production in Africa. Directly dated oil palm from Bosumpra extends the date of oil palm use to the ninth millennium BP in West Africa, and the analysis of the macrobotanical assemblage documents the importance of obtaining and processing incense tree fruits in these periods. While there are some indications of casual management of useful light-demanding trees, further research especially more complete wood charcoal analyses in conjunction with existing studies of lake sediments from Bosumtwi are essential to provide a finer resolution picture of local vegetation conditions and forest types over the Holocene.

Overall, this research has explored how relationships with oil palm and incense tree changed throughout the Holocene, testing previous hypotheses about the replacement of incense tree with oil palm as the more important resource in the later Holocene at Bosumpra. When patterns of plant use, especially of oil palm, were examined, changes in the later Holocene were readily apparent, when compared with contemporaneous Kintampo production and management practices. This suggests that there was a variety of subsistence practices and uses associated with oil palm for different populations occupying Ghana in the terminal LSA. Finally, with the beginning of more sedentary food production in the later Holocene, remains of pearl millet and cowpea at Bosumpra document the earliest appearance of thesedomesticates in the southern forested regions of Ghana, perhaps a subtle indication of early interaction and exchange of knowledge and resources between low-level food producers and the occupants of Bosumpra.

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Appendix A: Identified Plant Remains

Identified Plant Remains from Bosumpra		
Genus	Species	Common Name (English)
Bergia	*capensis*	
Canarium	*schweinfurthii*	incense tree
Cleome	*monophylla*	
Elaeis	*guineensis*	oil palm
Pennisetum	*glaucum*	pearl millet
Vigna	*unguiculata*	cowpea
Zaleya	*pentandra*	African purslane

Appendix B: Bosumpra Macrobotanical Remains by Phase[1]

					Domesticate Seeds (n)				Wild Seeds (n)										
	Unit	Layer	Horizon	Sample	*Pennisetum glaucum*	*Pennisetum cf. glaucum*	*Vigna unguiculata*	*Vigna cf. unguiculata*	*Bergia cf. capensis*	*Cleome cf. monophylla*	*Zaleya cf.pentandra*	Brassicaceae	Fabaceae	Poaceae	Ranunculaceae	Solanaceae	Unknown	Unidentifiable	**Total Seeds**
	1	3		503		1			1									6	**8**
	1	3		504							1		1	1	2			5	**10**
	1	2		516														6	**6**
	2	3		505					5	1			2		13			13	**34**
	2	3		506				1	5				3		12			33	**54**
	2	2		507		1			27		1		3	3	5			30	**70**
	2	2		508					5									5	**10**
	2	2		510		1			15					1			1	5	**23**
	2	2		517					4										**4**
	3	3		514		1			24									3	**28**
	3	3		515					6						1			2	**9**
	3	2		518					4									1	**5**
	3	2		522					6						1				**7**
	4	3		530															**0**
	4	2		532					13										**13**
	4	2		534					3		1				1				**5**
	4	2		536		1												3	**4**
	4	2		537															**0**
	5	3		531															**0**
Phase III post 2550 BP	5	3		533					1										**1**
	5	2		535					3					1					**4**
	5	2		538					4					1					**5**
	6	3		551															**0**
	6	2		552					11				1		1			4	**17**
	6	2		554					3						3			7	**13**
	6	2		560															**0**
	6	2		565					8						1				**9**
	7	3		556					7				1					3	**11**
	7	2		567	1				4										**5**
	7	2		569					2						1				**3**
	7	2		572															**0**
	8	3		595									1	1	1			1	**4**
	8	3		597					2						1				**3**
	8	2		598					3									3	**6**
	8	2		600											1				**1**
	8	2		602					1						1				**2**
	8	2		605															**0**
	8	2		607					3									1	**4**
	8	2		608															**0**
	8	2		610					2										**2**
	8	2		612					9						1				**10**
	Phase III TOTALS				**1**	**5**		**1**	**181**	**1**	**3**		**12**	**8**	**46**		**1**	**131**	**390**

[1] All soil samples taken for flotation were a uniform 10 l.

	Unit	Layer	Horizon	Sample	Domesticate Seeds (n)				Wild Seeds (n)										Total Seeds
					Pennisetum glaucum	*Pennisetum cf. glaucum*	*Vigna unguiculata*	*Vigna cf. unguiculata*	*Bergia cf. capensis*	*Cleome cf. monophylla*	*Zaleya cf.pentandra*	Brassicaceae	Fabaceae	Poaceae	Ranunculaceae	Solanaceae	Unknown	Unidentifiable	
Phase II 5285-2550BP	1	1	8	520					20									2	**22**
	1	1	8	524					12				1	2				2	**17**
	1	1	8	527					29		1				1			1	**32**
	1	1	8	588					10				2	1				3	**16**
	1	1	7	590	1	1			30									1	**33**
	1	1	7	623	1				13									3	**17**
	2	1	8	519					72				1					22	**95**
	2	1	8	523			1		4									7	**12**
	2	1	7	611					57		1			1	4		2	10	**75**
	2	1	7	613					230										**230**
	2	1	7	614					96									4	**100**
	2	1	7	615					73		1							1	**75**
	2	1	7	617					9									2	**11**
	2	1	7	619					7									8	**15**
	2	1	7	620					32									2	**34**
	3	1	6	673															**0**
	3	1	6	674							3	1					1		**5**
	4	1	6	540											1			1	**2**
	4	1	6	541					5						1				**6**
	4	1	6	543					21									1	**22**
	4	1	6	549*					4				1					2	**7**
	5	1	3	539					7		1				3				**11**
	5	1	3	542										1	4				**5**
	5	1	3	544					37							1		2	**40**
	5	1	3	583	1													1	**2**
	5	1	3	585					57						1				**58**
	5	1	3	586					22									5	**27**
	6	1	6	568					19						1			8	**28**
	6	1	6	570					46						1			3	**50**
	6	1	6	571					106										**106**
	6	1	6	573					38										**38**
	6	1	6	576					22										**22**
	6	1	6	577				1	15						1				**17**
	7	1	6	575										1					**1**
	7	1	6	578															**0**
	7	1	6	580					28										**28**
	7	1	6	582					18										**18**
	7	1	6	584					24						1			1	**26**
	7	1	6	587															**0**
	7	1	6	589					56										**56**
	7	1	3	591					58										**58**
	7	1	3	592					41						3				**44**
	7	1	3	594					27										**27**
	8	1	3	616					1										**1**
	8	1	3	618					6										**6**
	8	1	3	621					1										**1**
	8	1	3	622					11										**11**
	8	1	3	624					27										**27**
	Phase II TOTALS				**3**	**1**	**1**	**1**	**1391**		**7**	**1**	**5**	**6**	**22**	**1**	**3**	**92**	**1534**

	Unit	Layer	Horizon	Sample	Domesticate Seeds (n)				Wild Seeds (n)										Total Seeds
					Pennisetum glaucum	*Pennisetum cf. glaucum*	*Vigna unguiculata*	*Vigna cf. unguiculata*	*Bergia cf. capensis*	*Cleome cf. monophylla*	*Zaleya cf.pentandra*	Brassicaceae	Fabaceae	Poaceae	Ranunculaceae	Solanaceae	Unknown	Unidentifiable	**Total Seeds**
	3	1	5	675					3				2		3				8
	4	1	5	550					4									1	5
	4	1	4	553					10		1			1				1	13
	4	1	4	555					10									6	16
	6	1	2	579					65				1		1				67
	6	1	2	581					20									1	21
	6	1	2	645					11										11
	6	1	2	647					7									1	8
	7	1	2	596					22										22
	7	1	2	599					23									2	25
	7	1	2	601					8										8
Phase I 10,280-5285BP	7	1	2	603					8									2	10
	7	1	2	604					7										7
	7	1	2	649					4						1				5
	7	1	1	606					16										16
	8	1	2	625					6										6
	8	1	2	626					9										9
	8	1	2	628					10									1	11
	8	1	2	631					3										3
	8	1	1	632					9									1	10
	8	1	1	635					8									1	9
	8	1	1	637					3									4	7
	8	1	1	639					1										1
	Phase I TOTALS								**267**		**1**		**3**	**1**	**5**			**21**	**298**
					4	**6**		**3**	**1839**	**1**	**11**	**1**	**20**	**15**	**43**	**1**	**4**	**244**	**2239**

	Unit	Layer	Horizon	Sample	Tree Fruit Endocarp (g)			**Total Endocarp**	Plant Remains (g)	
					Canarium schweinfurthii	*Elaeis guineensis*	Unidentifiable Endocarp		Wood Charcoal (g)	Unidentified Charred Remains
	1	3		503		0.05	0.03	**0.08**	1.36	
	1	3		504	0.01	0.05	0.04	**0.1**	3.43	0.01
	1	2		516	3.08	0.23		**3.31**	7.23	0.01
	2	3		505		0.24		**0.24**	16.49	
	2	3		506				**0**	21.4	
	2	2		507		0.85		**0.85**	38.11	0.14
	2	2		508		1.87		**1.87**	33.28	0.03
	2	2		510			0.08	**0.08**	12.62	
	2	2		517	3.62	1.56		**5.18**	13.2	
	3	3		514		1.61		**1.61**	35.7	
	3	3		515		1.82	0.02	**1.84**	46.49	
	3	2		518		1.83		**1.83**	12.28	
	3	2		522			0.58	**0.58**	0.79	0.16
	4	3		530		4.95		**4.95**	17.54	
	4	2		532		5.62		**5.62**	31.09	0.02
	4	2		534	0.14	1.77		**1.91**	13.78	1.72
	4	2		536		3.18		**3.18**	3.09	
	4	2		537	0.26	3.4		**3.66**	2.12	0.3
	5	3		531	0.31	2.41		**2.72**	9.01	
Phase III post 2550 BP	5	3		533	1.03	5.32		**6.35**	13.83	0.04
	5	2		535	0.87	6.17		**7.04**	12.43	
	5	2		538	1.88	2.27	0.05	**4.2**	13.5	0.02
	6	3		551		1.67		**1.67**	4.06	
	6	2		552		1.15		**1.15**	6.89	0.01
	6	2		554	0.16	3.25		**3.41**	3.84	
	6	2		560	9.71	3.64		**13.35**	10.47	
	6	2		565	9.05	0.61		**9.66**	5.33	
	7	3		556				**0**	2.44	
	7	2		567	0.1	2.47	0.31	**2.88**	6.11	
	7	2		569				**0**	0.42	
	7	2		572	0.92	15.86		**16.78**	5.54	
	8	3		595		1.66		**1.66**	42.18	
	8	3		597		0.77		**0.77**	28.57	
	8	2		598		2.45		**2.45**	38.27	
	8	2		600		0.54		**0.54**	3.03	
	8	2		602				**0**	1.59	
	8	2		605		9.36		**9.36**	20.48	
	8	2		607	1.96	10.26		**12.22**	8.64	
	8	2		608	3.72	4.83		**8.55**	6.51	
	8	2		610	0.61	1.38		**1.99**	3.31	
	8	2		612	2.43			**2.43**	9.35	
	Phase III TOTALS				**39.86**	**105.1**	**1.11**	**146.07**	**565.8**	**2.46**

					Tree Fruit Endocarp (g)				Plant Remains (g)	
	Unit	Layer	Horizon	Sample	*Canarium schweinfurthii*	*Elaeis guineensis*	Unidentifiable Endocarp	**Total Endocarp**	Wood Charcoal (g)	Unidentified Charred Remains
Phase II 5285-2550BP	1	1	8	520	7.85		0.09	**7.94**	7.39	
	1	1	8	524	2.03		0.06	**2.09**	19.3	
	1	1	8	527	1.37			**1.37**	30.43	
	1	1	8	588	0.17	0.1	0.5	**0.77**	2.25	0.01
	1	1	7	590	0.03	0.01	0.01	**0.05**	0.15	0.01
	1	1	7	623				**0**	0.03	
	2	1	8	519	0.34		0.16	**0.5**	17.5	
	2	1	8	523	3.96	0.07		**4.03**	34.09	
	2	1	7	611				**0**	1.26	0.01
	2	1	7	613	0.38			**0.38**	0.85	
	2	1	7	614	5.95		0.87	**6.82**	3.57	
	2	1	7	615	0.6		0.02	**0.62**	0.15	
	2	1	7	617	1.18	1.18		**2.36**	0.09	0.02
	2	1	7	619				**0**	0.14	
	2	1	7	620				**0**	0.02	
	3	1	6	673	1.38		0.86	**2.24**	2.15	
	3	1	6	674	1.12	0.13		**1.25**	0	0.05
	4	1	6	540	7.13			**7.13**	2.48	
	4	1	6	541	3.35	0.5		**3.85**	0.37	
	4	1	6	543	1.19			**1.19**	1.19	
	4	1	6	549	0.07	0.2		**0.27**	0.04	
	5	1	3	539	9.87	1.17	0.22	**11.26**	7.05	
	5	1	3	542	18.81	1.12	0.02	**19.95**	2.42	0.01
	5	1	3	544	3.17	0.14		**3.31**	9.32	
	5	1	3	583				**0**	2.39	
	5	1	3	585				**0**	0.03	0.01
	5	1	3	586				**0**	0.05	
	6	1	6	568	0.68	1.12		**1.8**	2.36	0.01
	6	1	6	570	0.84			**0.84**	10.01	0.03
	6	1	6	571	0.88			**0.88**	0	0.01
	6	1	6	573	0.43			**0.43**	0.08	0.02
	6	1	6	576				**0**	0.02	
	6	1	6	577				**0**	0.02	
	7	1	6	575	0.39	33.73		**34.12**	3.46	
	7	1	6	578	0.59	17.47		**18.06**	2.12	
	7	1	6	580	16.94	7.57		**24.51**	29.92	
	7	1	6	582	10.43	1.59		**12.02**	0	
	7	1	6	584	14.61	0.78		**15.39**	45.05	
	7	1	6	587	6.93			**6.93**	23.53	
	7	1	6	589	5.12	0.21		**5.33**	7.32	
	7	1	3	591				**0**	6.95	
	7	1	3	592	1.6	0.01		**1.61**	3.36	
	7	1	3	594	3.22	1.17	0.01	**4.4**	3.42	
	8	1	3	616	10.16	0.1		**10.26**	3.48	
	8	1	3	618				**0**	1.37	
	8	1	3	621	9.06	0.36	0.03	**9.45**	4.45	
	8	1	3	622	3	0.58		**3.58**	0.21	
	8	1	3	624	2.89			**2.89**	0.58	
	Phase II TOTALS				**157.72**	**69.31**	**2.85**	**229.88**	**292.42**	**0.19**

	Unit	Layer	Horizon	Sample	Tree Fruit Endocarp (g)			**Total Endocarp**	Plant Remains (g)	
					Canarium schweinfurthii	*Elaeis guineensis*	Unidentifiable Endocarp		Wood Charcoal (g)	Unidentified Charred Remains
Phase I 10,280-5285BP	3	1	5	675	0.16			**0.16**	0.69	
	4	1	5	550	0.01			**0.01**	0.76	
	4	1	4	553	0.06			**0.06**	0.04	
	4	1	4	555	0.24	0.11		**0.35**	0.32	
	6	1	2	579	0.04			**0.04**	0.1	
	6	1	2	581	0.33			**0.33**	0.05	0.02
	6	1	2	645				**0**	0.03	
	6	1	2	647				**0**	1.38	
	7	1	2	596	5.5	0.53		**6.03**	2.71	
	7	1	2	599	2.53	0.42		**2.95**	1.41	
	7	1	2	601	0.17	0.32		**0.49**	0.09	0.03
	7	1	2	603	1.75	4.77		**6.52**	17.92	
	7	1	2	604	3.09	0.24	0.17	**3.5**	0.22	
	7	1	2	649		0.04		**0.04**	0.37	
	7	1	1	606	0.09			**0.09**	0.16	
	8	1	2	625				**0**	0.07	
	8	1	2	626	3.53	0.05		**3.58**	0.71	
	8	1	2	628	6.83	0.19		**7.02**	0.58	
	8	1	2	631	2.02			**2.02**	0.46	
	8	1	1	632	0.24			**0.24**	0.02	
	8	1	1	635	0.51			**0.51**	0.33	
	8	1	1	637	0.01			**0.01**	0.46	
	8	1	1	639			0.01	**0.01**	0.04	
	Phase I TOTALS				**27.11**	**6.67**	**0.18**	**33.96**	**28.92**	**0.05**
BOSUMPRA TOTALS					**224.69**	**181.08**	**4.14**	**409.91**	**887.14**	**2.68**