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The Archaeopalynology of Crystal River Site (8CI1), Citrus County, Florida

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ABSTRACT

The Woodland-period (ca. 1000 B.C. to A.D. 1050) fisher-hunter-gatherers of the Crystal River drainage on Florida’s Big Bend Coast are well known among southeastern archaeologists for their elaborate shell mound architecture, maritime lifeway, and exotic exchange goods. Recent archaeological investigations at the Crystal River site have employed high-resolution topographic mapping, geophysical surveys, trench excavations, and coring to model the temporality of mound construction and occupation at the site; this work has set the stage for subsequent research focusing on community structure, resource extraction, and human-ecosystem dynamics. However, like many central and north peninsular Gulf Coast sites, our understanding of Crystal River lacks robust environmental context. Various geologists and archaeologists have proposed that several major sea-level oscillations transpired during the late Holocene at scales that would have heavily impacted coastal habitation; however, the paleoenvironmental reconstructions available for the Gulf Coast disagree dramatically about the timing, extent, and general pattern of sea-level history, which discourages the use of non-localized (or averaged) reconstructions for archaeological interpretation. This study investigates palynological remains recovered from midden and wetland core samples taken at Crystal River site to provide a record of vegetation response to both externally driven environmental changes (i.e. sea-level and climate flux) and anthropogenic landscape alterations throughout the first millennium A.D. Results show that stratified midden deposits and wetland soils at Crystal River site contain intact fossil pollen assemblages that span the site’s occupational history and extend into pre- and post-abandonment periods. The pollen data suggest that local communities
experienced substantial environmental changes that reorganized the composition and geographic
distribution of coastal ecosystems. These transformations align well with broadly recognized
climatic episodes (i.e. the Roman Warm Period, Vandal Minimum, and Medieval Warm Period).
In contrast, the Crystal River drainage experienced a unique pattern of sea-level flux that does
not approximate oft-cited sea-level records developed elsewhere on Florida’s Gulf Coast, or the
averaged sea-level curves for the Gulf Coast. Additionally, the microbotanical remains preserved
within midden soils at Crystal River site may speak to the roles of particular plants as
subsistence, technological, medicinal, and/or ceremonial resources.
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CHAPTER ONE: INTRODUCTION AND RESEARCH QUESTIONS

Well over a century of archaeological research on Florida’s peninsular Gulf Coast has demonstrated that the ancient fisher-hunter-gatherer peoples of this region carried out diverse and dynamic maritime lifeways that interconnected profoundly with estuarine and marine ecosystems (see review by Thompson and Worth 2011). Acknowledging these socioecological traditions, and the ability of sea-level oscillations to reorganize coastal ecosystems, Florida archaeology has a legacy of drawing upon climate and sea-level reconstructions to aid the interpretation of social events and processes (Fairbridge 1974; 1976b; 1978; Griffin 1988; Marquardt and Payne 1992; Missimer 1973; Walker et al. 1994; Widmer 1988). Indeed, Late Holocene histories of sea level and climate on Florida’s Gulf Coast remain integral and/or coveted aspects of ongoing archaeological research programs in the region (e.g. Austin et al. 2014; Austin and Mitchem 2014; Marquardt 2014; McFadden 2015; Pluckhahn et al. 2015; Sassaman et al. 2011; 2014; Thompson and Turck 2009; Walker 2000; 2013). However, many of the paleoenvironmental reconstructions for the Gulf Coast are limited to marine proxies that do not substantively address climatic conditions (Balsillie and Donoghue 2004; Blum et al. 2001; 2002; Stapor et al. 1991; Tanner 1991; 1992); and many reconstructions differ considerably with regard to the extent, chronology, and even the general pattern of sea-level history on the Gulf Coast over the past 6000 years (e.g. Balsillie and Donoghue 2004; Davies 1980; Davies and Cohen 1989; Goodbred et al. 1998; Hine et al. 1988; Scholl and Stuiver 1967; Scholl et al. 1969; Stapor et al. 1991; Tanner 1991; 1992; Walker et al. 1995; Wright et al. 2005). My review of this variation among sea-level and climatic reconstructions (see Chapter Two) suggests that coastal...
physiographic variation may be a prime factor and that archaeologists looking to apply paleoenvironmental information to particular geographic areas should draw upon studies conducted within those regions as opposed to averaged models that attempt to represent the entire state’s Gulf Coastline.

For this thesis research, I sought a localized paleoecological/paleoenvironmental reconstruction that could provide signatures for: climatic conditions (i.e. temperature, precipitation, and storm activity), relative sea level, and the influence of human actors on the ancient coastal landscape. Palynology, the study of pollen grains, spores, and microscopic indicators, offers just such a methodology, enabling the diachronic reconstruction of vegetation communities. Vegetation community histories are particularly informative in paleoecology because plants—and particularly wetland plants—are highly responsive to changes in precipitation, temperature, hydrology, topography, salinity, fire frequency, nutrient availability, and various other factors (e.g. Fletcher et al. 1993; Kelly and Goulden 2008; Tiner 1999).

My reconstruction is centered at Crystal River site, a Woodland-period (ca. 1000 B.C. to A.D. 1050) village and ceremonial center (Figure 1.1) on Florida’s ‘Springs Coast’—the southern portion of the ‘Big Bend’ region characterized by an abundance of short, spring-fed river systems that empty into the Gulf. The site’s occupational history, recently defined by Pluckhahn and colleagues (2015), spans two millennia of the Late Holocene (ca. ~800 B.C. to A.D. 1070) that were reportedly characterized by major (perhaps eustatic) climatic and sea-level oscillations (see Little 2003 for a review). The deeply stratified midden deposits at the site and the wetland soils surrounding the mound center are well suited for the deposition and preservation of palynological remains. Indeed, the Crystal River/Salt River system as a whole poses an ideal locale for palynological analysis because of its extremely low energy regime and
its broad, flat topographic gradient (Davis et al. 1992; Goodbred et al. 1998; Hine et al. 1988; Hutton 1986; Tanner 1960). These conditions have led to the development of extensive marshlands (and thus marsh peat) that are dotted with and bordered by elevated hammock islands. The vegetation composition of the marshes and hammocks is zoned by topography and marine influence, that is, they are largely zoned by proximity to the open Gulf (Hine et al. 1988; Hutton 1986; Vince et al. 1989; Williams et al. 1999). As plant communities in the river system responded to external environmental oscillations (i.e. climatic or sea-level change) in the past, the timing and nature of these responses were preserved in the sedimentary record as assemblages of pollen grains settled and were buried by marsh, swamp, or anthropogenic soils.

Figure 1.1. Location of Crystal River Site (8CI1) and the Robert’s Island Complex
Pollen records, however, are also well suited for investigating anthropogenic ecological disturbance (e.g. clearing, burning, leveling, mounding, nutrient loading) and the use of particular plant taxa by ancient peoples (e.g. McLauchlan 2003; Whitmore et al. 1996). Thus, this study explores the pollen record at Crystal River site from a historical ecological perspective, where external (i.e. climatic, sea-level) factors, local ecological conditions, and human actors, all work simultaneously to construct the socionatural landscape. Chapter Three provides an expanded discussion of historical ecology and how I apply this body of theory to the archaeopalynological record at Crystal River.

Chapter Four describes the field methods (e.g. mapping, trench excavations, coring) and laboratory methods (e.g. sub-sampling, processing, microscopy) involved in this study. In Chapter Five, I report the composition of stratigraphic pollen assemblages and track temporal-stratigraphic changes in the relative abundance of different plant taxa. In Chapter Six, I draw upon pollen assemblages, archaeological data, and published paleoenvironmental reconstructions from the region to reconstruct changes in the local vegetation communities at and near the site and explore how broad scale environmental shifts manifested themselves in this particular river system, given unique geological-ecological succession processes and anthropogenic influence. I also discuss the evidence for anthropogenic disturbance at Crystal River site and track these signatures through the site’s proposed occupational history (Pluckhahn et al. 2015) to distinguish episodes of: intensive site activity, waning site activity, abandonment, and ecological recovery. More limitedly, I explore the palynological evidence for the use of particular plant taxa by ancient people at Crystal River site as technological, subsistence, medicinal, and ceremonial resources. Finally, in Chapter Seven, I propose archaeopalynology as a research methodology well suited for application in future coastal archaeological and paleoecological work; then I
make a case for the utility of archaeopalynology as a research tool available to Florida’s coastal
communities as they work to prepare for modern climate change.

**Research Questions**

This thesis seeks to reconstruct the socioecological landscape history of Crystal River site and the Crystal River/Salt River system throughout the Middle and Late Woodland periods (ca. 500 B.C. to A.D. 1050). The questions that follow guide my work. Notably, they cannot be adequately addressed by either archaeology or palynology alone, and require a blending of methodological considerations and theoretical/interpretive frameworks.

1. Does the pollen record at Crystal River site provide evidence for the local manifestation of major environmental fluctuations during the site’s occupational history (ca. A.D. 70-1070)?

2. If environmental changes are apparent, how do they align with available Gulf Coast oscillation curves and broad scale climate models?

3. If environmental changes are apparent, how do they fit into the history of site use and occupation at Crystal River site?

4. What evidence is there for the use of particular plants as subsistence and/or technological resources at Crystal River site?
CHAPTER TWO: BACKGROUND

The Crystal River Site (8CI1)

As early as the eighth century B.C., coastal foragers began constructing the sand and shell earthworks that make up Crystal River Site (8CI1). The village/mound center sits on the northern bank of the Crystal River about a kilometer from where the river divides into a maze of smaller channels separated by marsh/hammock islands, and about midway along the river’s short 9 km course – from its spring heads in King’s Bay to the open Gulf of Mexico and the Crystal River Embayment.

Over a millennium of what appears to have been relatively continuous occupation, Crystal River’s ancient communities planned and built the site’s mound features on a monumental scale, and with an impressive degree of elaboration in design (Pluckhahn and Thompson 2014). In its final stage---by about A.D. 800---the complex contained nine mounds, a well-defined plaza, and an expansive, deeply stratified shell ridge/midden feature (Figure 2.1).

Arriving from the river, an imposing 9-meter tall shell platform mound (Mound A), along with two smaller mounds (J and K) immediately to the west, rise above the marsh to dominate the viewshed from considerable distance. A lagoon (now filled) was located just east of Mound A and likely served as a main access point for people arriving and departing by canoe. The broad arching midden feature (feature B) runs southeasterly across the site separating the mounds nearest the riverfront (Mounds A, J, and K) from the remainder of the mounds and plaza features.
Figure 2.1. Topographic Map of Crystal River Site (8CI1) (Map Courtesy of Thomas J. Pluckhahn)
North of the midden, an expansive, leveled plaza is flanked to the north, east, and west by mounds. To the east, a low embankment encircles a conical sand mound, forming a composite burial complex (Mounds C-F). A low, circular, burial mound (Mound G) sits to the west of the plaza, and connects via shell causeway to the northern terminus of the plaza area and the base of Mound H, a rectangular-pyramidal platform mound with a ramp extending southward into the plaza.

The village complex sits on an elevated river bank hammock platform bordered to the north, east, and west by perennially flooded wetland areas, and to the south by the Crystal River. Modern disturbance has altered several areas of the site. In the western section the construction of an interpretive center and the road that leads to it has disturbed an expansive area with unknown potential for archaeological deposits. The development and use of a mobile home park in the eastern and southern section of the site is also responsible for disturbance at the site, largely affecting the midden feature (Weisman 1995). However, intact deposits remain below the leveled and filled trailer pads (Pluckhahn et al. 2015). Further disturbances at the site included the filling of the lagoon that enabled river access from the midden, and the destruction of at least one third of Mound A (Weisman 1995). Crystal River continues to exhibit clear differentiation of mound, plaza, and wetland areas, and the stratigraphy of the vast majority of site loci remain intact for archaeological sampling.

The monumental scale of the site features, along with the excavation of Hopewell-affiliated artifacts by C.B. Moore in the early twentieth century brought Crystal River fame among archaeologists and the public until the 1970s (Bullen 1951; 1953, 1966; Moore 1903, 1907, 1918). In the decades that followed, a paucity of continued publications from the site (and I would argue, the site’s geographic location away from modern population centers and
universities) left it shrouded in quiet intrigue. The site now returns to the limelight as the primary focus of the Crystal River Early Villages Archaeological Project (CREVAP), an intensive research program aimed at reconstructing the history of Precolumbian lifeways in the Crystal River/Salt River drainage using conservative sampling techniques and a diverse array of analytical strategies.

**Twentieth-Century Investigations**

Crystal River site became famous after excavations into the Main Burial Complex (Mounds C-F) by the antiquarian C.B. Moore in the early 1900s. In addition to the 400 plus burials unearthed by Moore and his workers, the excavations yielded hundreds of Hopewell-affiliated ornaments crafted from extra-local materials such as silver, copper, and large quartz crystals. These finds placed the site within the interaction sphere of Middle and Late Woodland period networks extending for thousands of miles, perhaps as far as the Great Lakes region (Moore 1903, 1907, 1918).

Moore also drafted a remarkably accurate map of the site, and documented the existence of the lagoon feature along the riverfront. While it is easy to condemn Moore for his inadequate methods and his blatant disrespect toward mortuary contexts and human remains, as archaeologists, we owe a debt to him for recording many important pre-Columbian sites, and for producing large-scale drawings of the artifacts he excavated. He is more than likely the main reason that Crystal River and dozens of other sites in the American Southeast are known to us today.
Ripley Bullen excavated at Crystal River in the 1950s and 1960s, but unfortunately took very few notes, preferring to work from memory. The primary record of Bullen’s work is comprised of a few sketch maps, a number of photos, and a few short articles (Bullen 1951, 1953, 1966). With Bullen’s passing in 1976, the data, impressions, and interpretations held in his powerful memory were also lost to us. Of Bullen’s work at the site, perhaps the most circulated records are from his excavations at one of the Stela, which bears a clearly anthropomorphic etched design. The etching (which may or may not actually be Precolumbian), continues to
stimulate scholarly intrigue (Pluckhahn 2014), however, it is not the focus of any rigorous modern archeological investigation.

**CREVAP**

Recent NSF-funded research at the Crystal River site organized by the Crystal River Early Villages Archaeological Project (CREVAP) has employed modern technology and conservative sampling techniques to develop an thorough understanding of the site’s occupational history and the chronology of mound construction (Pluckhahn 2014; Pluckhahn and Thompson 2010; Pluckhahn et al. 2015). As part of the CREVAP my research ties into the chronometric data, culture history, and interpretation produced from the project’s digital mapping, geophysical remote sensing, excavation, and coring programs.

Numerous radiocarbon dates obtained from trench excavations into Feature B and coring in the non-burial platform mounds enabled Pluckhahn and colleagues (2015) to develop a Bayesian statistical model for the chronology of site construction and occupation at Crystal River. The phase modeling divides occupation of the village into four phases, described below, that I rely upon for chronological control of midden core stratigraphy, and for comparing local socioecological signatures with site history and broader environmental conditions (Table 2.1). Following convention (Healy et al. 2011), I use italics for the Bayesian modeled dates; to differentiate these from singular calibrated radiocarbon dates.

*Phase 1.* Phase 1 began between *cal A.D. 65 and 244* (95 percent confidence intervals), probably between *cal A.D. 125 and 199* (68 percent confidence intervals). It ended between *cal A.D. 144 and 265* (95 percent confidence intervals), probably between *cal A.D. 180 and 242* (68 percent confidence intervals) (Pluckhahn et al. 2015).
Table 2.1. Bayesian Phase Chronology for Crystal River Site (Data from Pluckhahn et al. 2015)

<table>
<thead>
<tr>
<th>Phase</th>
<th>Modeled 1σ Ranges (cal A.D.)</th>
<th>Modeled 2σ Ranges (cal A.D.)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Start</td>
<td>End</td>
</tr>
<tr>
<td>1</td>
<td>125-199</td>
<td>180-242</td>
</tr>
<tr>
<td>2</td>
<td>238-292</td>
<td>441-499</td>
</tr>
<tr>
<td>3</td>
<td>521-605</td>
<td>671-747</td>
</tr>
<tr>
<td>4</td>
<td>779-867</td>
<td>902-982</td>
</tr>
</tbody>
</table>

This phase represents the first few centuries of settlement at Crystal River, when occupants began depositing midden materials along the river bank. As mentioned briefly above, Mound G and the Main Burial Complex seem to predate Phase 1, and were likely important components of the landscape well before semi-permanent occupation (Figure 2.3a). Pluckhahn and colleagues (2010), following Milanich (1999:20), suggest that rising sea level through the first centuries A.D. and shortening proximity to estuary resources had profound effects on mound construction, social organization, and the prominence of the site in regional interaction. There is convincing evidence (with widespread agreement) that sea level did rise in the region and elsewhere on the Gulf Coast during the first few centuries A.D. (i.e. Goodbred et al. 1998; McFadden 2015; Stapor et al. 1991; Tanner 1991; 1992; Walker et al. 1995), and it is entirely plausible that external environmental change helped instigate the initial occupation at Crystal River. However, the construction and use of the burial mounds before this period suggests that the location was an important part of the cultural landscape before this marine transgression (and intensive occupation) took place (Pluckhahn et al. 2015).

Phase 2. Phase 2 began between cal A.D. 221 and 321 (95 percent confidence intervals), probably between cal A.D. 238 and 292 (68 percent confidence intervals). It ended between cal
A.D. 435 and 544 (95 percent confidence intervals), probably between cal A.D. 441 and 499 (68 percent confidence intervals) (Pluckhahn et al. 2015).

These deposits represent about two hundred years of intensive occupation with an increase in the occurrence of ceramic, bone, and shell artifacts. Pluckhahn and colleagues (2015) propose that during this time the resident community at Crystal River expanded and/or began living at the site permanently. Notably, stable isotope geochemical analysis on oyster (Crassotrea virginica) shell from mound and midden loci at Crystal River corroborate this interpretation, showing clear evidence of perennial midden deposition in Phase 2 (Thompson et al. 2015). Mound H (at the northern edge of the plaza) and Mound K (atop the western midden) were constructed during Phase 2, and the midden was built up and expanded eastward along the shore of the former lagoon (Figure 2.3b) (Norman 2014; Pluckhahn et al. 2015). Norman’s (2015) pedological analysis of a core taken in Mound A suggests that the midden was expanded toward the river bank during Phase 2 to form a base for the later construction of the large platform mound. These landscape modifications---notably the mining and direct use of midden materials for monument construction---complicate the modern conceptual separation between ‘mound’ and ‘midden,’ and suggest that villagers at Crystal River were executing a sophisticated and planned site design with clear distinction between mounded, plaza, and wetland areas.

Phase 3. The third phase of occupation at Crystal River began between cal A.D. 479 and 634 (95 percent confidence intervals), probably between cal A.D. 521 and 605 (68 percent confidence intervals). It ended between cal A.D. 663 and 809 (95 percent confidence intervals), probably between cal A.D. 671 and 747 (68 percent confidence intervals) (Pluckhahn et al. 2015). During Phase 3 midden deposition continued at Crystal River, but was more limited than the previous few centuries. It appears that people began relocating to the nearby Robert’s Island
mound complex, as suggested by radiocarbon dates from an early midden feature at the site (Figure 2.4a) (Pluckhahn et al. 2015:32-34). Simultaneous with this relocation, people completed the construction of the nine-meter-tall Mound A at Crystal River Site. While the construction of Mound A likely consumed much of the shell that would have represented this occupational phase in Feature B, the decreased prevalence of ceramics, shell and bone tools, and flaked stone within Phase 3 loci strongly suggests diminishing occupational use through the sixth–ninth centuries A.D. (Figure 2.3c).

**Phase 4.** The final phase of occupational activity at Crystal River began between cal A.D. 722 and 881 (95 percent confidence intervals), probably between cal A.D. 779 and 867 (68 percent confidence intervals). It ended between cal A.D. 890 and 1068 (95 percent confidence intervals), probably between cal A.D. 902 and 982 (68 percent confidence intervals) (Pluckhahn et al. 2015).

The final ~100 years of occupation at Crystal River seem to have been characterized by dramatically reduced activity at the site, as the deposits dating to this phase are quite thin, and are restricted to the area immediately adjacent to mound A (Figure 2.3d). Construction at Robert’s Island, however, expanded dramatically during phase four, and “appears to have supplanted Crystal River as a ceremonial hub” (Figure 2.4b) (Pluckhahn et al. 2015:34). There are very few cultural deposits at Crystal River useful for evaluating socioenvironmental events and processes during Phase 4. However the hydric hammock/freshwater swamp wetlands to the north and east of the site yield palynological remains dating to this period, and may speak to post–‘abandonment’ ecological processes (i.e. forest regeneration, etc.).
Figure 2.3a-d. Crystal River Site-Feature Phase Modeling (maps courtesy of Thomas J. Pluckhahn)
The occupational phases identified at Crystal River and Robert’s Island transpired during a period characterized by several broad-scale environmental transitions. Further, it is clear that human communities living in the Crystal River/Salt River drainage substantially altered their landscape; but, this alteration was likely done in myriad ways and to an extent not readily apparent to us in the present. The focus of this study, in part, is to investigate the interaction of ‘external’ and anthropogenic landscape transformations. The following section discusses external environmental forces, i.e. sea-level and climatic oscillations, that work upon antecedent geology and sediment supply to influence local ecosystems. These external conditions, while not necessarily determinative, likely influenced personal and community decisions about subsistence.
resources, technology, and political economy. Further, they may have played a more direct role in influencing the permanence and intensity of occupation through time.

**Reconstructing Late Holocene Gulf Coast Sea Level and Climate**

Archaeologists working on the peninsular Gulf Coast have understood the pivotal importance of estuarine and coastal ecosystems in the lives of ancient forager communities since the onset of anthropologically focused excavations in the region, led by Frank Hamilton Cushing in the last decade of the nineteenth century (Cushing 2000 [1896]). Cushing, in the minds of many Florida archaeologists, was a generation (or two) ahead of his time (see Widmer’s contribution to Cushing 2000:ix-xxii). He realized immediately that the artifacts he was recovering from southwest Florida mound sites were the remains of a culture exceptionally well-tuned to the rhythms of the Gulf, even positing that many of the small islands of the northern Ten Thousand Islands region represent fully anthropogenic features of the coastal landscape. Since then, researchers analyzing paleo-environment, subsistence and settlement patterns, technology, and art/iconography have built a rich body of scholarship demonstrating complex social-ecological interconnection on Florida’s Gulf Coast (see review by Thompson and Worth 2011).

A new wave of environmentally-focused archaeologists in the region are building on this legacy of socionatural investigation, and are striving to make archaeology relevant to the threat posed by modern climate change and the projected effects of sea-level rise on the low-gradient Gulf coast (e.g. Duke 2016; McFadden 2015, 2016; Norman 2014; Sassaman et al. 2011; Wallis et al. 2015). The challenge for modern researchers in this region, as elsewhere, is to develop methodologies that empirically link the histories of ancient communities to the environmental changes they faced, while uncovering the ways people managed and manipulated their landscapes. If we want to propose the past as prologue in addressing modern climate change, we
must provide reliable reconstructions of ancient environments along with reconstructions of how human communities dealt with these transformations.

Florida’s Gulf Coast exhibits a range of distinct coastal environments, and the nature of each is largely controlled by antecedent geology and sediment supply, though the influence of climate and mean sea level (MSL) cannot be understated. These factors determine the distribution of coastal ecosystems and drive successional patterns (Evans et al. 1985; Hine et al. 1988; Leonard et al. 1995). Many Gulf Coast archaeologists draw upon sea-level reconstructions to aid the interpretation of various social events and processes, with the understanding that even relatively minor sea-level fluctuations transformed the landscape and required considerable social responses. Indeed, one reason for my interest in Crystal River site is that it seems people continuously occupied the village through a millennium characterized by major swings in sea level and climate.

Numerous researchers have developed curves for climatic and sea-level history that archaeologists apply to the Gulf Coast (Balsillie and Donoghue 2004; Blum et al. 2001, 2002; Brooks et al. 1979; Colquhoun and Brooks 1986; DePratter and Howard 1981; Donoghue et al. 1998; Gayes et al. 1992; Otvos 1995; Stapor et al. 1991; Scholl et al. 1969; Tanner 1991, 1992, 1993; Walker et al. 1994, 1995). These reconstructions involve various environmental, archaeological, and geological proxies, and are based in datasets collected at different coastal locales along the Gulf of Mexico and the Atlantic Ocean. The most prominent oscillation episodes are thought to involve eustatic factors (see Balsillie and Donoghue 2004; Little 2003) because of concurrent episodes in Europe, the Northwest coast of North America, and elsewhere (Crowley and North 1991; Crumley 1987; Gunn 1994, 1997; Lamb 1995; Stothers 1984; Ters 1987).
Early sea-level reconstructions for the Gulf Coast were based in analyses of Everglades/Florida Bay sediment stratigraphy and led researchers to propose a relatively ‘smooth’ and consistent rate of sea-level transgression over the past 11,000 years, with peak MSL occurring in the present (Davies 1980; Robbin 1984; Scholl et al. 1969; Scholl and Stuiver 1967; Shepard and Curray 1963). The influence of sea level figured prominently into the first major socionatural archaeological synthesis for Southwest Florida (i.e. Widmer 1988). Widmer’s evolutionary-ecological model attempted to explain how the Calusa of Southwest Florida developed and maintained a degree of sociopolitical complexity without the support of agricultural production. He relied upon generalized sea level curves available at the time (the ‘smooth’ curves above) to posit that sea level stabilized at ~2700 BP (Widmer 1988:181-223) and enabled: the steady production of estuary resources, consequent population expansion, and eventually the development of ranked, then chiefdom-like political organization.

However, years before Widmer’s seminal work on Calusa prehistory was published, R.W. Fairbridge (1974, 1976a, 1976b, 1978) and other archaeologists working in Southwest Florida (Griffin 1988:38, 235, 340; Missimer 1973; Ruppé 1979:41-42) had come to take issue with the ‘smooth’ reconstructions for the Gulf Coast after excavating evidence for late Holocene sea-level stands at both higher and lower positions than present.

Continued research in Southwest Florida renewed the skepticism brought by Griffin, Ruppé, and Missimer and refined Widmer’s model (see Marquardt 2014 for a review), exploring correlations between settlement patterns, resource extraction data, and sea-level oscillation episodes. This recent work has benefitted from the development of sea-level oscillation curves from Pine Island Sound, a locale at the heart of Calusa territory (e.g. Stapor et al. 1991; Tanner 1991, 1992; Walker et al. 1995), finding that sea level never ‘stabilized’ (a relative term to be
sure) in this area, but continued to fluctuate at scales significant enough to drive major shifts in settlement patterns and affect the distribution and availability of subsistence and technological resources (Marquardt 2010, 2014; Marquardt and Walker 2012, 2013 Walker et al. 1994, 1995).

Proposed Late Holocene Sea-level Episodes

Proxy records of high and low sea-level stands in Southwest Florida suggest the occurrence of at least four relevant sea level episodes on the Gulf Coast during the Late Holocene from ca. 1000 B.C. to A.D. 1950. These episodes are commonly referred to (sometimes interchangeably) by terms denoting contemporaneous global-scale climatic episodes. In the interest of clarity, I base my review of sea-level oscillations in terminology specific to the Gulf Coast, and refer to broader ‘global’ terms when referring specifically to climatic conditions. Below I provide chronological descriptions of the major sea-level oscillation episodes documented in Southwest Florida and references for the role of eustatic factors.

Sanibel 1 Low Stand – ca. 3000-2000 B.P. The Sanibel 1 episode, as described by Stapor and colleagues (1991), refers to a sea-level stand observed in beach ridge deposit morphology (beach ridge sets) on barrier islands along Charlotte Harbor and Pine Island Sound. They suggest that sea level sat about 40-60 cm below modern MSL until 2000 B.P.---the projected start of the Wulfert High (this is the earliest sea-level stand recorded by existing beach ridges in the region). Walker and colleagues (1994) refined the timing of this low stand in south Florida through the analysis of midden stratigraphy, mollusk remains, and radiocarbon samples at the Wightman Site, also located on Sanibel Island. Their estimate for the duration of the low stand places it between 3000 and 2000 B.P. Tanner’s (1991, 1992) analysis of beach ridge sets on St. Vincent Island in Northwest Florida also addresses this low stand; his beach ridge ‘Set D’ sits below modern MSL (by no reported exact measure) and is dated to ca. 2300-2000 B.P. Walker and
colleagues (1995) synthesize the above records along with archaeological analysis at the Solana site to extend the Sanibel 1 low stand until ca. 1850 B.P., maintaining that sea level stood 40-60 cm below present.

DePratter and Howard (1981) report a low stand on the Atlantic Coast of Georgia between 3000 and 2400 B.P. and Books and colleagues (1979:85) report reduced MSL on the coast of South Carolina between 2700 and 2300 B.P. Low sea-level stands and attendant cool and dry climatic conditions during this period are also noted in Europe (Crumley 1994:240; Gunn 1994:17; Lamb 1995:153; Ters 1987:225-226), suggesting that eustatic factors played a major causal role in the low MSL stand and climatic cooling during this period.

Wulfert High Stand – ca. 1850-1350 B.P. The Wulfert High Stand, known climatically as the Roman Warm Period or the Roman Optimum, encompasses approximately the first half millennium A.D. Stapor and colleagues’ (1993:835) beach ridge studies find local sea level reached 1.2 m above MSL during this episode. The seven-point floating average curve for the Gulf Coast produced by Balsillie and Donoghue (2004:14), and a beach ridge study by Tanner (1993:228) from the coast of Denmark report similar findings in support of the Wulfert High stand. Tanner’s (1992) St. Vincent Island beach ridge Set E sits above modern MSL and was reportedly deposited between 2000 and 1250 B.P. Walker et al. (1995:215) project a more recent occurrence for the Wulfert High on the Gulf Coast, reporting a rise to ~modern MSL between 1850 and 1750 B.P., followed by continued transgression to 70 – 137 cm above modern MSL between 1750 and 1450 B.P. Brooks and colleagues (1989:94) document a concurrent high stand on the Atlantic coast of South Carolina; and European locales also yield evidence for high sea-level stands along with warm and wet climatic conditions (Crumley 1987:240; Lamb 1995:162-165; Ters 1987:227) suggesting eustatic influences.
Buck Key Low Stand – ca. 1350-1100 B.P. The Buck Key Low, known broadly as the Vandal Minimum (Gunn 1994:17), is generally associated with sea-level regression and cool and dry climate. However, the climate during this period is perhaps better thought of as highly variable, and the support for sea-level regression on the Gulf Coast is less consistent (see following section). Stapor and colleagues (1991:872), Tanner (1993), Balsillie and Donoghue (2004), and Walker and colleagues (1995) all report evidence for a sea level regression 50-60 cm below modern MSL between ca. 1350 and 1100 B.P. Tanner (1992) reports that a beach ridge set on St. Vincent Island (Set F) sitting below modern MSL was deposited between 1250 and 900 B.P. Contemporary glacier advances in Greenland and in nearly all of Earth’s major mountain range systems, among other proxy data, suggest strongly that eustatic factors drove this cooling episode (Crowley and North 1991:95; Meese et al. 1994:1681; Wanner et al. 2011), and that it may have to do with the AD 536 atmospheric dust event (Stothers 1984).

In contrast to the evidence for cool and dry conditions at many locales across the globe, Wang and colleagues’ (2011:9; 2013) stable isotope analysis of faunal remains from southwest Florida archaeological sites suggests that the Vandal Minimum was locally punctuated by warm climate and frequent precipitation between 1350 and 1300 B.P. before cool and dry conditions returned at ca. ~ 1250 B.P. (Walker et al. 1995). This brief warm and wet event demonstrates notable variability within the Vandal Minimum climatic episode, yet it is unclear whether or to what extent the brief climatic variation between 1350 and 1300 B.P. was reflected in sea level.

During the projected time frame for the Buck Key Low many coastal sites in the Tampa Bay area (Austin et al. 2014; Austin and Mitchem 2014), Southwest Florida (Marquardt and Walker 2013), and the Big Bend region (McFadden 2015) lack evidence for intensive occupation. The lull in occupational intensity at these geographically separated sites is variously
interpreted as a social response to sea-level regression, sea-level transgression, or excessive climatic variability, showing that conditions along Florida’s Gulf Coast were anything but homogenous during the Vandal Minimum.

La Costa High Stand – ca. 1100-500 B.P. The La Costa High, broadly known as the Medieval Warm Period (Gunn 1994:17), describes a sea level transgression between ca. 1100 and 500 B.P. (Stapor et al. 1991:835). This high sea-level stand is proposed to have been lesser in scale than the Wulfert High, reaching less than half a meter above modern MSL. The La Costa High coincides with a period of warm and wet climate documented in Europe (Crumley 1987:240; Lamb 1995:185) and likely represents part of a global-scale climatic change. Notably, this period coincides with the renewed occupation at several sites in the Tampa Bay area sitting just above modern MSL (Austin et al. 2014; Austin and Mitchem 2014).

Persistent Issues

Much of what Florida (and southeastern) archaeologists understand about Late Holocene Gulf Coast sea level and climatic fluctuation comes from the body of research reviewed above. However, if we survey a broader swath of research and look critically at the accepted reconstructions, it becomes clear that the chronology, scale, and general pattern of sea-level history over the past 6000 years in the Southeast United States remain contentious and uncertain.

The timing of well-accepted Gulf Coast sea-level episodes in Southwest Florida (i.e. Stapor et al. 1991; Tanner 1991, 1992; Walker et al. 1995) appear offset from Atlantic Coast reconstructions (i.e. Brooks et al. 1989; Colquhoun et al. 1995; DePratter and Howard 1981) by at least 300 to 400 years (atop a century or so of uncertainty in radiometric dating). This may have something to do with methodological constraints or chronological dating error; but if we credit these researchers by generally accepting their findings, it seems most probable (and is
hardly surprising) that these episodes were experienced at different times because of geographic/physiographic separation, distinct coastal geologies, and the functioning of different coastal processes.

How though, might we explain variation within major coastal regions? On the Atlantic coast of the Carolinas and Georgia, Gayes and colleagues (1992), as well as DePratter and Howard (1981) propose a smooth rise to present MSL from the low stand at ~2500 B.P. Colquhoun and Brooks (1986), however, report evidence for at least three significant fluctuations subsequent to 2500 B.P. within this same region. Likewise, Florida Gulf Coast studies also disagree with one another over the general pattern of sea-level history. Thompson and Worth (2011:54, fig. 2a) plot some of the commonly cited sea-level curves for the Gulf Coast to show how drastically they vary (by as much as 6 m during concurrent episodes within the past 2000 years). Even the oft-cited sea-level reconstructions most utilized by researchers in Southwest Florida (i.e., Tanner 1991, 1992; Stapor et al. 1991) disagree over the timing and scale of certain fluctuations. Walker and colleagues (1995) plot these curves (along with an adapted hypothetical curve) showing consistent mismatches of timing on the order of 200 to 400 years, and significant disagreement (~30-60 cm) over the scales of sea-level change during the Sanibel 1 low, the Buck Key low, and the La Costa High. The temporal disagreement may partially result from the heavy use of relative dating methods and an assumption of cyclicity in sea-level episodes by Stapor et al. (1991) (notably, multi-proxy eustatic paleo-climate research [Wanner et al. 2011] does not support cyclical patterning during the Holocene). However, the disagreements between Tanner (1991, 1992) and Stapor and colleagues’ (1991) reconstructions over the magnitude of sea-level stand fluctuations cannot be well explained by methodology (as both rely upon beach ridge morphology), and thus likely have to do with minor differences in local coastal processes.
between sampling locations. It will surprise few readers who have traveled along Florida’s Gulf Coast that reconstructions from St. Vincent Island on Florida’s panhandle (i.e. Tanner 1992) do not exactly match reconstructions from Charlotte Harbor/Pine Island Sound in Southwest peninsular Florida (Stapor et al. 1991; Walker et al. 1994). Indeed, it is somewhat remarkable that these two reconstructions—separated by the majority of Florida’s Gulf coastline—agree about the occurrence and general timing of regressive and transgressive events. However, we should not take this as evidence for uniform coastal response to sea-level changes, as both study sites are barrier island beach dune systems. An examination of these two separated coastal regions shows that they share similar geologies and energy regimes, and thus are quite likely to have experienced sea-level fluctuations in similar ways (Tanner 1960). The remainder of Florida’s Gulf Coast, including the Big Bend region, is underlain by different geological formations and experiences a variety of energy regimes—all responding differently to sea level and climatic changes over the last 6000 years.

*‘Alternative’ Sea-Level Histories*

The most significant disagreement among Gulf Coast sea-level reconstructions exists between the beach ridge-set studies discussed above (Pine Island Sound and St. Vincent Island) and pedological research from South Florida (Everglades and Florida Bay) and the north peninsular Gulf Coast (Big Bend Coast). Pedological studies involve coring landscape features (often wetlands) and the analysis of sediment strata (often referred to as ‘facies’) to assess their formational and developmental history in terms of biotic/abiotic conditions and processes. I call these reconstructions ‘alternative’ here because the modern paleo-environment discourse in late Holocene Gulf Coast archaeology is dominated by global climatic episodes (i.e. RWP, VM, and MWP) and the ‘beach ridge’ sea-level curves from Pine Island Sound and St. Vincent Island,
along with Tanner’s (1993) reconstruction from Denmark. In this discourse, several sea-level reconstructions from the Florida Everglades (Davies and Cohen 1989; Enos and Perkins 1979; Scholl and Stuiver 1967; Scholl et al. 1969) are sometimes cast tacitly as outdated, incomplete, or inadequate science (Marquardt 2014; Stapor et al. 1991; Walker et al. 1995); further, rigorous paleo-shoreline reconstructions from other regions (Goodbred et al. 1998; Hine et al. 1988; Wright et al. 2005) that generate findings more similar to these ‘smooth’ deceleration curves are very seldom acknowledged.

The early ‘smooth’ sea-level curves for the Gulf Coast were produced from the analysis of sediment cores taken in the western Florida Everglades---from the Big Cypress Swamp/Ten Thousand Islands region south to Florida Bay. Stuvier and Scholl (1967:439) examined the stratigraphy of piston cores taken in marsh and swamp locations collected throughout the region, focusing especially on cores taken “along the edges of bays and water ways dissecting [the marsh/swamp wetlands].” The stratigraphic analysis shows that freshwater wetland peats (deposited at or above MSL) were transgressed by ‘paralic’ (brackish water---effectively mangrove deposited) peats, and then by marine sediments. When coupled with radiocarbon dating (see Scholl 1965 and Scholl et al. 1969) and spatial analysis, these results show that this area of the peninsula has experienced a purely transgressive sea-level pattern over the mid-late Holocene characterized by a relatively dramatic slow-down around 4000 B.P. After this deceleration, sea level continued to rise at a steadily diminishing rate, with no episodes of greater than present MSL.

Davies and Cohen (1989), along with Enos and Perkins (1979) analyze the geomorphology and pedological stratigraphy of Florida Bay sediments. They document facies transitions from freshwater environments (ponds/marshes/swamps) to coastal mangrove swamps,
then to open marine environments. These marine environments then may experience a number of depositional processes, including mud bank formation and island development. The development of mud banks and island formations is technically a regressive depositional sequence; however, the development of these formations is indicative of continued, but slowed, sea-level rise and the influence of vegetation and storm events, and does not indicate reduced MSL (Enos and Perkins 1979).

On Florida’s Big Bend coast (the north peninsular Gulf Coast) marine geologists have constructed a detailed history of environmental change from 4400 B.P. to the present from sediment cores taken in embayment, marsh, levee, and hammock-island locations (Evans et al. 1985; Goodbred et al. 1998; Hine et al. 1988; Hutton 1986). The sedimentary facies changes in this region resulted from fluctuating rates of marine transgression and the effects these episodes had on the region’s distinct geomorphology and biotic communities. Between 4400 and 1800 B.P., the Big Bend region experienced a period of relatively slow sea-level rise, while other west Florida coastal systems were becoming established and/or experiencing sea-level regression (Goodbred et al. 1998; Hine et al. 1988). The slow development of brackish and marine systems from freshwater forested swamps, along with the abundance of large oyster reefs (bioherms) during this period, suggest that the coastal environment was relatively stable and that the transgression rate was quite slow. In the Suwanee River mouth area a slowed rate of sea-level rise between ~5000 and 2500 B.P. is corroborated by the gradual development of coastal marshes, which requires relative sea-level stability (Wright et al. 2005). Notably, this period of slowed and gradual transgression and marsh development corresponds with the onset of occupation at sites like Butler Island and Garden Patch between ca. 45 B.C. and A.D. 75 (McFadden 2015).
Between 1700 and 1800 B.P. Goodbred and colleagues (1998) document dramatic basin-wide sedimentary changes in the Waccasassa River/Bay system (the next major drainage north of Crystal River). At this time brackish marshes (brown-black peaty deposits) near the gulf shore transitioned to open salt marsh (grey and green mud deposits). Further inland, peaty facies indicative of brackish marsh deposits are established above pre-Holocene sandy muds, or directly atop limestone outcrops. Goodbred and colleagues (1998) calculate a rate of shoreline retreat between 10 and 20 meters/year, resulting in the marine-influenced intertidal setting we recognize today by ~1800 B.P. Wright and colleagues (2005) corroborate this finding, documenting that a transgressive pulse occurred at the mouth of the Suwanee River at ~1600 B.P. McFadden (2015) connects a period of intensified occupation and rapid mound construction at the Garden Patch site (ca. A.D. 240) with the environmental changes brought by the 1700-1800 B.P. transgression, which notably would have brought estuarine resources to much closer proximity.

This pulse in the Waccasassa Basin corresponds temporally with the global Roman Warm Period and the Wulfert High at St. Vincent Isl. and Pine Island Sound, but does not match the sea-level scale proposed by the beach ridge studies (Stapor et al. 1991; Tanner 1991, 1992; Walker et al. 1995). The scale of transgression proposed by Goodbred and colleague’s (1998) study helps explain the depth of midden deposits at Crystal River site. The early (ca. A.D. 65-265) deposits extend 1.5 m below the modern ground surface, reaching below the modern water table to the elevation of the modern river. If sea level sat above modern MSL to the degree proposed by beach ridge studies during this time, then the initial midden deposits would have been laid down into a meter or more of river water. Given the possible subsidence of midden deposits over time, this is an interesting notion, and poses a hypothesis worth testing (see
Chapters 5 and 6), but ultimately seems unlikely given the preservation of midden materials and the strong data reported by marine geologists working in this sub-region (e.g., Goodbred et al. 1998; Hine 1988; Hutton 1986; Wright et al. 2005).

After this sea-level pulse, shoreline retreat slowed, and Goodbred and colleagues (1998) note no further shifts in facies position, except for the slow transgression of seaward peaty facies by marine sediments around at a calculated rate of 0.5-2 meters/year (similar to the period between 4400-1800 B.P.). Indeed, the extensive development of brackish marshes and oyster bioherms after the 1800-1700 B.P. event suggest a return to relative stability. The only regional evidence for potential sea-level pulse later in time comes from Butler Island marsh deposits, where McFadden (2015) documents a transition from freshwater marsh to brackish conditions landward of the island at ca. A.D. 660-770.

Localized Paleo-Environmental Reconstructions

As demonstrated above, true sea-level regression episodes (not simply slowed/stalled transgression) and greater-than-present sea-level stands during the late Holocene remain contentious ideas for the Everglades, Florida Bay, and the Big Bend region of Florida’s Gulf Coast. The disagreement between beach ridge studies and pedological analyses may indeed have some roots in methodological differences and in the different geological features being sampled. Beach ridge studies, naturally, have been done high-energy barrier islands (accumulations of beach ridges) while pedological/sedimentological research has been done in a greater diversity of environments, both below and above modern MSL. Because beach ridges are exceptionally vulnerable to unusually strong depositional and erosional events (e.g. hurricanes and northeasterly storms) they seem inherently predisposed to record local extremes. In contrast, stratigraphic sequences in sediment cores (e.g. those discussed from: Everglades National Park,
Florida Bay, and the Big Bend coast) are predisposed to record longer term episodes and patterns that substantially affected the local environment by altering hydrological regime, salinity, and vegetation communities. Sediment stratigraphy, of course, also records events of relatively short duration, but only if they resulted in deposits, erosional non-conformities, or discernable environmental/ecological changes. What most inhibits agreement over a generalized (peninsula-wide) Gulf Coast sea-level history during the late Holocene is that the beach ridge studies suggest that dramatic transgressive and regressive events (i.e., the Wulfert High and Buck Key Low) lasted for several hundred years---more than enough time to substantially transform local environments and leave clear stratigraphic/pedological markers. Yet, the stratigraphic records at many sampling locales suggest entirely transgressive late Holocene sequences with notable pulses and slowdowns, but no true regressions and no stands higher than modern MSL.

Efforts to explain the discord are sorely lacking, and instead of emphasizing how sea level and climatic oscillations were (and likely will be) experienced variably at local scales, much energy has been devoted to creating and applying averaged cumulative curves for the entire coastline (e.g., Balsillie and Donoghue 2004; Donoghue 2011). While interesting to think about, these averaged curves do not offer applicability for specific archaeological investigations, and arguably may do more harm than good if used to address modern/future sea level rise in particular regions.

With intensifying archaeological and paleo-environmental interest on the central, north-central, and Big Bend Gulf Coast, archaeologists are confronted with the need for environmental reconstructions specific to these research areas (Austin et al. 2014; Monés et al. 2014; Norman 2014; Pluckhahn et al. 2015; Sassaman et al. 2011). From a historical-ecological perspective ‘global’ climatic episodes and scaled up reconstruction curves from nearby sub regions may
provide some very general interpretive guidance for archaeologists, but they may also mislead, and should not be related to past sociocultural dynamics without empirical evidence for how people in particular areas actually experienced environmental change. In contrast, localized interdisciplinary research offers the opportunity to understand how sea-level fluctuations affected local environments and inspired social responses by coastal forager communities (e.g. McFadden 2015).

The Big Bend Coast

The Big Bend of Florida’s Gulf Coast is a 300 km–long open marine marsh coastline stretching between the central peninsular Gulf Coast and the panhandle (Hine et al. 1988). The region sits at the geographic center of the Floridan formation—-an expansive (350,000 km²) Mesozoic/early Cenozoic shallow-water carbonate platform. The unique geologic history of this section of the platform has left Eocene-age Ocala and Suwannee limestone formations shallowly buried or outcropping at the surface (Chen 1965; USGS 2014). Following the Late Paleogene filling of the Suwanee Straits by sediments eroding off the southern Appalachians, shallow water carbonate deposition effectively halted and quartz sand coastlines developed. During Quaternary sea-level stands these quartz sands were deposited along the Brooksville ridge (a band of erosion-resistant carbonate rock); thus, the platform west of the ridge was deprived of sedimentation and experienced extensive karstification. Because of this karst geology and the close proximity of the Floridan aquifer to the surface in this region, all but one of the major streams that feed the coastal systems begin at spring heads only a few kilometers from the coast. The Suwanee River, the exception here, emanates from the expansive Okefenokee wetlands of southern Georgia and is joined by several tributaries along its course before emptying into the Big Bend marsh coast system about 20 km north of Cedar Key. The spring fed drainages carry
very little suspended siliciclastic load, depriving the coastal systems of sediment supply. Thus, sedimentation in the marsh and Island Hammock systems of this region occurs almost exclusively by vegetation (i.e. wetland peat/muck building) and marine-driven processes (storm surges during tropical and extra-tropical storm events) (Goodbred and Hine 1995; Hine et al. 1987).

The broadness and low-gradient of the drowned continental shelf in this region, along with the distinct lack of silicate sediment, and the relatively limited fetch of the Gulf of Mexico combine to produce an exceptionally low-energy coastline without the barrier island-lagoon systems that dominate coastal regions to the south and in the panhandle. Hine and colleagues (1988) identify four distinct geomorphological features: Berm-Ridge Marshes, Marsh Peninsulas, Marsh Archipelagos, and Shelf Embayments. Each of these is characterized by distinct floral and faunal communities, and is affected somewhat differently by sea-level transgression and sedimentation. The Crystal River and Salt River drainages---the focus of this study---feed an extensive marsh archipelago system and the Crystal River Embayment. The USDA (2014) identifies the terrestrial areas within Crystal River system as part of the Palmico marine terrace, which is composed of clayey sands that slope generally seaward. At the Crystal River Site itself, the USDA, NRCS (2012) and Pilny and colleagues (1998) identify three dominant soil types: Quartzipsaments, forming zero to five percent slopes, are relocated sandy soils characteristic of urban areas; Matlacha are also sandy urban land complex soils, but are characterized by a shallower limestone substrate; Okeelanta mucks make up the wetland areas surrounding the site, and are characterized by poor drainage and shallow limestone substrates (generally within 80 cm). As noticed during previous geoarchaeological research at the site (i.e. Norman 2014), these soil descriptions are not highly informative. However, they do generally
distinguish wetland from upland site areas and reflect the extent to which ancient and modern peoples have modified the landform through the relocation of sediments and the introduction of midden, mound, and construction fill materials.

Marsh Archipelago Vegetation Patterns

The marsh island system in this area is characterized by a distinctive spatial pattern of vegetation communities influenced by elevation, hydroperiod, and salinity (Hine 1988; Hutton 1986). The zoned description of vegetation communities that follows was constructed through reviews of geological (Hine et al. 1988; Hutton 1986), biogeographical (Myers and Ewel 1990), and ecological literature from the local region (Vince et al. 1989; Williams et al. 1999), as well as several informal personal surveys along the course of the Crystal River/Salt River system.

Nearest the spring heads, freshwater marshes are dominated by Typha spp. with Freshwater sedges (e.g. Rhynchospora spp.) and emergent aquatics like Sagittaria spp, Saururus cernuus, and Pontederia cordata occupying shallow ponded environments. With increasing proximity to the open gulf and marine influence the marshes become more brackish and support dense expanses of Cladium mariscus and other generalist sedges like Eleocharis spp. and Cyperus spp. Nearer to the open gulf, nearly homogenous swaths of Juncus romerianus form the salt-marsh, typically with a thin fringe of Spartina alternafloa. At the marsh/open gulf interface intertidal islands support some of the northern-most mangroves (Rhizophora mangle) on the Gulf Coast, along with Spartina spp. and sea-grasses.

The marshes in this region are dotted with hammock islands, which sit on topographic highs in the limestone substrate and hold enough sediment to support a fresh water table for several tree species. Like the marshes, the vegetation on these hammock islands is spatially patterned according to marine influence. The least haline hammocks support the greatest
diversity of tree and herbaceous taxa, of which *Magnolia grandifolia*, *Celtis* spp., *Quercus* spp., and *Carya* spp. are common. With increasing proximity to the open gulf, non-haline species cannot survive, and species diversity declines. The main tree taxa surviving on the haline hammock islands are *Quercus virgiana* (Live Oak), *Juniperus silicicola* (Southern Red Cedar), and *Sabal palmetto* (Sabal Palm). The Live Oaks are least salt-tolerant, and die out first as island hammocks become transgressed by rising sea level; Southern Red Cedars do prefer relatively saline niches, but cannot survive beyond a certain hydroperiod and salinity; and the Sabal Palm is most salt-tolerant – dying out only once drowned by inundation (Vince et al. 1989; Williams et al. 1999).

Because these plant communities are so sensitive to salinity, hydroperiod, and elevation, the pollen preserved within Crystal River site’s deposits contains a record of past environmental changes as expressed by plant communities. This pollen record, combined with the chronological modeling of occupation at Crystal River and select radiocarbon dating on core samples, enables me to look for signatures of sea-level flux and human landscape modification during the site’s occupational and post-occupation history.

**Why Archaeopalynology?**

As sessile organisms, plants have evolved to utilize external actors to transport genetic material for reproduction; they do this by packaging their microscopic (~10 to 100 μm) male gametophytes---pollen grains---for transportation. The ideal destination is an ovule of a female flower/cone of the same species. Because the pollen grain must persist and remain viable through a host of difficult environmental conditions before fertilization, plants construct the outer-most cell wall of pollen grains---called the *exine*---largely from a poorly understood biopolymer named *sporopollenin*. This compound has evaded attempts to understand the exact nature of its
biochemistry (see Prahl et al. 1985; Guilford et al. 1988), and is one of the most chemically resilient biopolymers known to science (see Bedinger 1992). The durability of the pollen exine explains their preservation in a range of Quaternary, and older, contexts, which has enabled palynologists and archaeo-palynologists to track environmental changes through time at various scales.

The morphology of the pollen exine is highly variable and is diagnostic taxonomically. The forms are distinguished morphologically at a number of scales. At the most basic divisions, grains exhibit different numbers and types of openings in the exine, which enable the growth of the ‘pollen tube’ that aids fertilization after a pollen grain has reached the stigma (female receptive structure). Exine openings may take a number of shapes---most often circular pores or linear furrows---and may occur in various numbers. The number and type of openings distinguishes grains only at very broad taxonomic levels. For instance, monocot plants (typically non-branching plants with one seed leaf and an adventitious root system) are commonly typified by monosulcate or monoporate pollen grains, which exhibit a single linear furrow or circular pore respectively (Figure 2.5). Eudicot plants (plants with two seed leaves and considerable variation in stem and root morphology) produce pollen with a diverse range of morphology, typically including multiple furrows or pores (tricolpate – three furrowed – pollen is very common) (Figure 2.6). Identifying pollen grains beyond very basic taxonomic divisions requires assessing various less obvious characteristics, including: size, shape, surface texture, and wall thickness, along with dimensions of the exine openings.

The adaptive strategies of particular plants are key to interpreting pollen records. This is because plants produce variable quantities of pollen, and rely upon different transportation actors to facilitate fertilization. The two main types of pollen transport strategies especially relevant to
this study are insect pollination (entomophily) and wind pollination (anemophily). Wind pollinated taxa are most typically the foci of palynological reconstructions because pollen grains from these plants are released into the air and form what is called the pollen rain, which is affected by a range of processes not limited to wind patterns, topography, canopy cover, and precipitation before eventual deposition in terrestrial or aquatic systems. Animal pollinated taxa are typically under-represented in natural deposits because their pollen is seldom mobilized into the wind-driven pollen rain. Entomophilous pollen may be found, however, in deposits which accumulated below stands of the pollen producing plants themselves; and some animal pollinators (bees in particular) may dislodge pollen to the extent that the plant becomes “factitively anemophilous,” as occurs in certain Salix spp. (Argus 1974; Faegri and Iversen 1989:12).

Figure 2.5. Monosulcate Pollen Grain – Pontederia cordata (Pontederiaceae)
I would like to highlight a few additional pollen transportation considerations I feel are particularly relevant to this research. First, in forested locales tree species tend to dominate the pollen rain; this situation has to do, obviously, with the dense concentration of trees, but also with the role of the canopy in subduing the flowering of anemophilous understory taxa and preventing the deposition of pollen rain from nearby open areas (Faegri and Iversen 1989:14-16). With the disturbance of forest cover, the location opens up for the proliferation of understory vegetation and increased deposition of pollen rain. This generally means that forest clearing and forest regeneration events are typically recorded rather well in palynological records and should be detectible in the occupation-period deposits at Crystal River. Secondly, the pollen from plants with relatively short habits typically becomes deposited at or very near the ground elevation where the pollen was released. Several experimental studies (Hicks and Hyvärinen 1986:225; Hyde and Williams 1945; Potter 1967) have shown that depositional loci at even slightly higher elevation (as little as 1.1 meters) receive a small fraction of ground cover pollen in comparison to the ground surface. This consideration is important for analyzing the pollen record of elevated
site features at Crystal River, which rise several meters above the marsh and plaza ground surfaces.

The relationship between past plant abundance and the relative abundance of its preserved pollen—the theoretical variable \( R \) (Davis 1963)—cannot be reliably quantified, and analyzing the pollen record from any stratigraphic layer requires the consideration of processes affecting: plant flowering, pollen release, the pollen rain, deposition, taphonomy, and sampling procedure. In anthropogenic deposits, and those near human activities, \( R \) also must incorporate the intentional and unintentional effects of human actions. These can be direct, and involve the harvesting, burning, encouragement (i.e. cultivation), or transportation of vegetation. The effects can also be indirect, resulting from modification of the landscape (e.g. forest clearing and altering topography/hydrology) or altering soils with midden materials (e.g. addition of plant remains themselves, adding carbon and nutrients, changing pH, etc.). In this way humans affect the pollen record on multiple fronts: they influence the actual composition of local plant communities, and then alter the flow of the pollen rain, and control depositional and taphonomic processes (see Faegri and Iversen 1989:175-199). This study deals exclusively with anthropogenic deposits, and directly with shell midden strata; as such my interpretations aim to address local and regional environmental conditions as filtered through human actions.

Most plant material handled, processed, or discarded by humans at a depositional environment will leave behind some trace in the pollen record. In anthropogenic deposits, the pollen record is particularly valuable because macrobotanical preservation is inconsistent and inherently skewed toward plants gathered for seeds or woody tissue, which become carbonized in hearth contexts and are thus preserved (Miksicek 1987; Scarry 1993). The pollen record, however, has the potential to represent plants which do not preserve macroscopically. This
includes both environmental indicator species and plants that may have been used for their roots, shoots (rhizomes, corms, tubers, bulbs, etc.), leaves, thorns, meristematic tissue (immature inflorescences, etc.), or flowers. In coastal contexts, and particularly on the marsh coast home to Crystal River, emergent aquatic plant taxa (e.g. *Typhaceae*, *Alismataceae*, *Cyperaceae*, *Juncaceae*, *Nymphaceae*, etc.) were likely important technological and dietary resources (see Hutchinson et al. 2016 for recent stable isotope evidence). These are not plants with desirable seeds or woody tissue, so the only material remains of their local presence or use are microbotanical elements including starch grains, phytoliths, and pollen. Of the microbotanical elements available for analysis, fossil pollen is the best suited for preservation at Crystal River. This is because both starch grains and phytoliths are predisposed to vegetative reabsorption in saturated alkaline deposits, while pollen grains are not.
CHAPTER THREE: HUMAN-ECOSYSTEM INTERACTION AT CRYSTAL RIVER

I approach the microbotanical-archaeological record at Crystal River with a historical-ecological perspective, investigating the dialectical relationship between human society and the environment to produce novel historical and scientific knowledge about the past (Balée 1998; Crumley 1994, 2007). Both archaeological investigations (e.g. Erickson 2000; Redman 1999) and ethnographic research (e.g. Fowler 2000) have shown convincingly that forager societies function as powerful ‘keystone’ biotic agents within variously scaled ecosystems by manipulating and managing local environments. From this view, ancient biophysical systems like the Crystal River/Salt River drainage may be conceptualized much like social structure in that they create, and are created by, human actions (Balée 1998).

Historical ecology is a broad and somewhat nebulous concept, and is often thought of and treated as a framework (e.g. Balée and Erickson 2006) as opposed to more formal theories. This framework of inquiry and interpretation is utilized by researchers from a variety of historical and scientific disciplines, most commonly: paleoecology, limnology, palynology, anthropology, archaeology, and environmental history. Within anthropology and in archaeology more specifically, researchers take a range of interpretive pathways under the historical ecological label by variably balancing the influence of sociohistorical and physical factors. These approaches all share the underlying assumption “that neither environment nor culture is the sole determinant of change in human societies.” (Marquardt and Walker 2013:5). The pursuit of the human–environment dialectic and an appreciation of the “mutually constitutive” relationship between these forces is what unifies historical ecology and separates it from the determinism and
practical constraints of cultural ecology, evolutionary ecology, and cultural materialism (Marquardt and Walker 2013:5-8).

Historical events and processes continuously shape and re-shape the dialectic between human societies and their biophysical environments (Balée 1998; Crumley 1994). These events and processes may be externally driven (i.e. geology and climate), instigated directly via human agency, or brought about by non-human biota, soils, and/or hydrology (Gunn 1994). Human groups act upon and historicize even the most external---geological, atmospheric, and astronomical---forces (e.g. climate and sea-level flux) to an extent that the concept of adaptation as used in various cultural materialist approaches is a relatively poor (and scientifically inaccurate) concept for looking at past human lifeways anthropologically. Thus, the socioecological approach I take here conceptualizes the effects of sea level rise and climatic fluctuations as components working on, and being worked upon by, a dynamic ancient landscape.

In historical ecological terms, landscapes can be broadly defined as “material manifestations of the relations between humans and the environment” (Crumley 1994:5; Crumley 1987). Patterson (1994:223-237) expands the concept by delving into the “unobservable” (i.e., immaterial) components of landscapes; he terms the material and immaterial components as totalities. These are encompassing unities that include all of the “dialectically structured and historically determined…interpretations, connections, and contradictions that join [various] constituent parts” of biocultural systems (Patterson 1994:230). *Historical ecology, or landscape history,* is the multidisciplinary effort to understand how landscapes, and larger totalities, change over time.
Below I lay out my framework for addressing the role of external drivers (i.e., sea level and climatic flux) within the Crystal River/Salt River drainage. Then, I explain my perspective for exploring more explicitly sociocultural processes (i.e. occupational intensity, subsistence, technology, etc.) through the analysis of microbotanical data.

**Externally-Driven Biophysical Changes and Human Landscapes**

The astronomical, atmospheric, and geological forces that influence climatic conditions and sea level have truly external components that make them tempting (and occasionally appropriate) causal mechanisms in socioecological models (Gunn 1994:65-97). However, the ways human groups, and the landscapes they manage, react to these external events (whether they pose challenges or opportunities) are conditioned by sociohistorical variables (Marquardt and Walker 2013:5-6). Thus, in regionally focused investigations the most thorough explanations for biocultural processes lie within the interaction between larger-scale ‘external’ events and local-scale, ‘internal’ (sociohistorical), structures.

The study of local, regional, and global climatic conditions is considered by Crumley (1994:12-13) to be a pertinent example of a *scalar hierarchy*, where “any level can affect any other level.” Crumley implores us to avoid uncritically placing levels of analysis into *control hierarchies* – systems where higher level processes dictate those of lower levels – because the confusion of these two very different relational systems often leads researchers in various historical, humanistic, and (predominantly) scientific fields to posit unfounded series of causation that over-simplify complex, sometimes *heterarchical* systems – potentially unranked, or variably and conditionally ranked relational systems (Crumley 1994:12-13).

This thesis research involves assessing the nature and timing of sea-level and climatic fluctuations on the Big Bend Gulf Coast, which were driven in the ancient past predominantly by
non-anthropogenic (likely eustatic) forces (but see Lewis and Maslin [2015] and Ruddiman et al. [2015] for discussions on ancient human impacts on the earth system). However, the regional manifestation of these forces depends upon interaction with local biological systems, soils, and hydrology – each of which are intertwined with deep histories of human influence (i.e. alteration, modification, and management) within the landscape. Thus, I do not assume that sea-level and climatic conditions played a directly formative or determinative role in the sociocultural trajectory of coastal forager communities of the Springs Coast. Instead, I focus on how sea-level and climatic flux interacted with the local human landscape over time. In this way, externally-driven climatic/sea-level conditions, antecedent geology, non-human biota, soils, and hydrology combine with the lifeways of ancient human communities at Crystal River to constitute a scalar or perhaps heterarchical regional totality.

At Crystal River, the construction of monumental site features extends perhaps as far back as 800 B.C., the earliest radiocarbon date ranges on burial remains from the Main Burial Complex (Katzmarzyk 1998:33; Milanich 1999:23; Pluckhahn et al. 2009:table 5-1). While no occupational remains have yet been dated to these early centuries, Crystal River was clearly an important early ceremonial node for local coastal foragers at this time, figuring prominently into the cultural landscape and perhaps drawing together dispersed small communities for mortuary rites and other ritual events. Downstream, the Crystal River and Salt River systems may have supported various small forager settlements contemporaneous with the early mortuary use of Mounds C-F and Mound G; however, a rigorous and systematic archaeological investigation of the riverbank and marsh island hammocks nearer the open gulf (which perhaps would have been ideal brackish ecotones at this time) has yet to be launched.
Through a millennium of occupation at Crystal River site, people transformed the village markedly through monument construction, midden deposition, and the differentiation of mound, plaza, and wetland areas (Norman 2014; Pluckhahn et al. 2015). There are clearly sociopolitical implications involved in the planning and construction of mounds and midden features, but there are also far-reaching socioecological impacts to be considered. Intensive resource harvesting, ecological modification, and perhaps management activities taking place in the wetland and estuary systems of Crystal River were necessary for site occupants to support perennial occupation, host feasting events, and facilitate monument construction (see Duke 2016; Jenkins 2016; Mahar 2016). The deforestation of the site (and likely many adjacent areas), along with the leveling (plazas) or mounding of different site features also would have transformed the soil and vegetation ecology on the local scale. Harvesting of trees and herbaceous plant stands, along with burning, and myriad hunting activities also would have transformed upland and wetland ecological systems, including riverbank and marsh island hammocks as well as the mixed temperate forests of nearby inland areas (see Boivin et al. 2016 for a global perspective on human niche construction). All aspects of site construction and resource harvesting in the Crystal River drainage constitute a continuous progression of historical-ecological events. Each of these events: was shaped by past socioecological phenomena, structured contemporaneous human-environment relationships, and conditioned the nature of future interactions. Given these considerations, my assessment of late Holocene sea-level history as experienced at Crystal River must be taken as a reconstruction of climate and sea-level flux as filtered through local geomorphological conditions and local biological systems working intricately within an anthropogenic landscape. By taking this approach I seek to transcend environmental determinist and cultural-evolutionist thinking and produce a more holistic reconstruction of human-
environment interaction during the Middle and late Woodland period (ca. 500 BC – AD 1050) at Crystal River.

**Palynological Signatures for Occupational Intensity and Ancient Plant Use**

The broad strokes of occupational history at Crystal River Site have been painted by previous CREVAP research through chronological modeling with radiocarbon assays (Pluckhahn et al. 2015), the analysis of ceramic assemblages (Kemp 2015; Thompson 2016), faunal analysis (Compton 2014; Duke 2016; Reitz and Brown 2015), and stable isotope geochemistry (Thompson et al. 2015). This body of work has established a strong framework for understanding the history of Crystal River as a ceremonial center, regional civic node, and village. The microbotanical record preserved within the midden at Crystal River has the potential to contribute much-needed environmental resolution to the work of CREVAP by addressing sociocultural processes and their relationship to broader-scale environmental fluctuations. However, midden formation also appears to have facilitated the preservation of microbotanical residues from subsistence, crafting, and perhaps ceremonial activities. In this section I first consider the theoretical underpinnings of interpreting occupational intensity and physical landscape modification in the pollen record; then I pivot toward my foundations for investigating subsistence, crafting, and potentially ritual remains through microscopic socioecological indicators.

It is essential, first, to dismiss two pervasive themes in western conceptions of hunter-gatherer-fisher societies. The concept of the ‘noble savage’, powerful since the inception of anthropology as a discipline, persists in popular consciousness and encourages people to envision and depict pre-Columbian societies (along with various historical and modern groups) as harmonious with their environment and decidedly non-exploitative (see reviews by Ellingson
The ‘noble savage’ concept was further developed in anthropology through the acceptance and popularity of cultural ecological and cultural materialist assumptions (Harris 1968; 1974; Odum 1972) that natural selection favors human populations existing at socioecological equilibrium (see Widmer 1988 for an example from the Gulf Coast). Conversely, another popularized model presumes that humans are innately exploitative and inherently cause environmental degradation, ultimately undermining the sustainability of complex society (e.g., Diamond 1994; 2005; Redman 1999).

These two major forms of western cultural bias were used historically to justify the systematic disenfranchisement of North American indigenous groups by separating them from their traditions, lands, and access to resources (Lewis 1994; White 1983); and have been used more recently abroad as part of neocolonial policies to appropriate tracts of land for extractive industry, ‘conservation’, and eco-tourism (see Igoe 2004). These biases continue to prevent many social, natural, and physical scientists (as well as civic leaders and the public by extension) from acknowledging: the anthropogenic formation of many types of ecosystems, the validity and utility of traditional-ecological knowledge, and the overwhelming cultural diversity of hunter-gatherer-fisher societies (Balée 1998:22-23; Balée and Erickson 2006).

At Crystal River, my aim is not a quixotic search for some sort of equilibrium between ancient villagers and the local environment, nor is it my intention to show how unsustainable practices or poor responses to external forcing brought about collapse. I do, however, hope to tease out socioecological signatures of the anthropogenic transformation of the landscape. Ecologically, these transformations are typically characterized as disturbance. This term refers to the successional reaction of biota to the relatively sudden opening of ecological niches; here, I’m referring specifically to vegetation clearing, leveling, and mounding at ‘on-site’ areas. In these
situations (all too familiar in our modern lives) generalist, quick-establishing, and fast-fruiting plant species (i.e. ‘pioneer species’) proliferate before being replaced in succession by more stable vegetation as disturbance subsides. The specific pioneer taxa vary, of course, by a host of ecological variables, including climate, elevation, hydrology, fire frequency, salinity, pH, etc. Thus, the diachronic record of disturbance marker species at Crystal River should enable me to reconstruct the history of site ‘disturbance’, which I hypothesize will correlate with the intensity of occupation and activity as assessed via trench excavation and the analysis of stratigraphy, ceramics, faunal remains, and radiocarbon samples (Duke 2016; Norman 2014; Pluckhahn et al. 2015). Further, the composition of the disturbance taxa in particular strata---accompanying my analysis of wetland vegetation patterns---will aid my reconstruction of the climatic, hydrological, and soil conditions during the phases of activity at the site.

Addressing subsistence, technology, and ritual through archaeo-palynological analysis will require crossing a few bridges of inference, and (shame on me) some imagination. However, several factors (i.e. good chronological control, an understanding of the pollen transportation processes of specific taxa, and analogy to ethnohistoric records) combine to make these crossings less arduous.

The first two factors here were explained at some length in the previous chapter, and I explain their specific application to the analysis of particular microscopic indicators in Chapters 5 and 6. The use of ethnohistoric records from Florida and the greater Southeast to support my interpretations, however, deserves some treatment here.

It seems logical, as noted by Hawkins (1964:343), that elements of historical documents cannot be treated as empirical scientific data, and thus should not be used to falsify or verify hypotheses. However, both general and direct-historical approaches to ethnohistoric analogy are
regularly utilized to “strengthen the analogies and inferences through the use of relevant empirical data” (Charlton 1981:153). There is a strong body of research utilizing general direct historical approaches—which utilize records directly pertaining to the region of interest that were collected either during the time period under investigation (e.g., Crumley 1974, 1994:6; Deagan 1973), or from descendant populations (e.g. Black 1967). Even the earliest relevant ethnohistoric records postdate the florescence of occupation at Crystal River by about a millennium, complicating the analogy between Woodland societies and contact period indigenous groups. Furthermore, the centuries leading up to European contact were characterized by substantial sociocultural transformations in the southeast, including agricultural intensification and a focus on maize as a stable crop. However, given the evidence for long term continuity in subsistence strategies and technological resource selection on Florida’s Gulf Coast (Hutchinson 2004; Hutchinson et al. 2016; Thompson and Worth 2011; Widmer 1988), the reported observations of early Spanish and French expeditions in Florida, along with later historic ethnographic accounts from the Southeast are fairly sensible records to draw upon as interpretive aids.

Because I am working with core samples with strata representing once open depositional environments, I can speak only limitedly and suggestively about subsistence, technology, and ritual plant use. This is because the presence of a particular plant’s pollen, phytoliths, or even its chemical signature, in an open context do not speak directly about specific cultural uses, though the presence and prevalence of certain taxa may strongly suggest cultural usage in general. In the future, testing residue on grinding stones or ceramics (e.g. Wells et al. 2014) from Crystal River may lend greater clarity and power to the subsistence and technology related interpretations here.
CHAPTER FOUR: METHODS

Archaeological studies addressing the histories of anthropogenic landscapes seem to almost always require the blending of traditional archaeological methods with methods from other scientific or humanistic fields (Crumley 2004; Faught and Carter 1998; Wells et al. 2000). For this thesis, looking into the history of multi-scalar environmental change at Crystal River requires sensitive and well-preserved ecological proxy data; and stratigraphic archaeological palynology offers access to just such a data set (see Kooistra and Kooistra 2003; McLauchlan 2003; Saunders et al. 2009; Scharf 2010). In this chapter, I describe both field and laboratory methods carried out to produce my analysis.

Field Methods

This thesis research builds upon fieldwork planned and executed by CREVAP predominantly during the 2011 summer field season. Their 2011 fieldwork incorporated geophysical surveys, total station mapping, coring, and trench excavations.

CRAVAP Excavations

In order to investigate the composition, chronology, and variability of the midden (Feature B) deposits at Crystal River CREVAP opened four trenches along its length (as defined by LiDAR, total station mapping, and core stratigraphy) (Pluckhahn et al. 2015). The trenches were excavated in 1-x-1 meter units, and were extended variably to dimensions between 1-x-2 and 1-x-4 meters. The excavated material was screened through .32 cm (.125 in.) mesh, and two trenches were selected for the excavation of 25-x-25 cm column samples, which were excavated
in levels no thicker than 4 cm, with all sediment retained for specialized analyses (Pluckhahn et al. 2015). In the other two trenches, the superpositioning of features negated the utility of column samples, but soil samples were collected from features.

Trench 1 was excavated into the best preserved (and most elevated) portion of midden/shell ridge on the west end near Mound K (Figure 4.1).

Figure 4.1. Topographic Map of Crystal River with Trench Locations (figure courtesy of Thomas J. Pluckhahn).

In Trench 1(Figure 4.2), three upper strata composed of dense shell uncomfortably overlie a dark, organic-rich, buried A (Ab) horizon with minimal shell (Stratum IV) (Pluckhahn et al. 2015). Features (likely post holes) extend from this layer into underlying dense-shell-
deposits (Stratum V). Trenches 2, 3, and 4 exhibit in situ stratigraphy quite similar to that of Trench 1, despite some modern disturbance (truncation, leveling, and fill) in the upper portion of Trench 2.

Indeed, because of the “relatively clear and undisturbed stratigraphy” in Trench 1, this location was chosen as the primary focus of the CREVAP chronometric dating program following the 2011 field season (Pluckhahn et al. 2015:27). A total of 36 radiocarbon dates were obtained from Crystal River midden samples, with 22 of these taken from Trench 1. While the analyses on eastern oyster (*Crassostrea virginica*) shell samples yielded widely variably results, bone collagen and soil carbon samples corresponded with each other and demonstrated a clear
trend of increasing age with depth (see Pluckhahn et al. 2015:fig. 14). These dates, along with dates from other trenches and core samples enabled Pluckhahn and colleagues (2015) to develop the Bayesian phase-based chronological model previously discussed in Chapter 2, which I will revisit in my results and discussion chapters.

*Coring at Crystal River*

Also during the 2011 summer field season, students and volunteers of CREVAP collected 58 soil cores at Crystal River intending to improve the understanding of mound construction, landscape history, and site chronology (Norman 2014). The CREVAP team, assisted by Glen Doran from Florida State University, took cores systematically at 20 m intervals across the plaza, midden, and adjacent areas; they also took cores into the summits of Mounds A, H, J, and K (Figure 4.3). Burial Mound G and the Main Burial Complex (Mounds C-F) were intentionally excluded from testing in order to avoid disturbing human remains. Four cm diameter terrestrial or ‘upland’ cores were taken in mounds, the plaza, and the midden. These were punched and extracted with a GeoProbe Model 6620DT hydraulic coring system, which was towed into place by motorized vehicle (Figure 4.4). GeoProbe cores were taken in 114 cm-long sections; some mounded site areas required as many as three sections to reach the underlying limestone, while others required only a single core section. Crucially, the team collected additional cores opportunistically from marsh and swamp wetland areas bordering the site. Because it was not feasible to move this machine into the wetland soils surrounding the terrestrial site features, a hand-operated (and custom built) Vibracore machine was used to take single section (1-2 m) cores from select wetland loci on the periphery of the terrestrial site features (Figure 4.5).
Figure 4.3. Map of GeoProbe and Vibracore Core Locations (map courtesy of Thomas J. Pluckhahn)
Figure 4.4. GeoProbe Coring System in use at the Crystal River Site

Figure 4.5. VibraCore Sampling near the Marsh-Hammock Interface at the Crystal River Site
Laboratory Methods

Preventing Contamination

Contamination is a central concern for pollen analysis; extreme care must be taken to protect against introducing modern pollen and to prevent the mixture of pollen grains from different contexts within the sediment core (Faegri and Iversen 1989:72-73). CREVAP workers guarded against the most common avenue of microbotanical contamination by keeping the sediment cores sealed throughout the fieldwork process and postponing sample processing until the cores were in the more-controlled laboratory setting.

In the lab, after splitting the cores lengthwise, taking photographs, and making stratigraphic determinations, Norman (2014) sampled each strata he discerned. During this process, he took proper precautions to avoid contamination between core strata during sampling by wearing and changing out personal protective equipment (gloves, etc.) and taking each sample with a clean instrument. Norman sampled one half of each core stratigraphically for sieving and artifact analysis, and sampled the second half for future research – bagging each of these stratigraphic samples in a separate sterile archival quality plastic bag. I encountered these curated core samples three years after their extraction and was elated to hear that the bags had remained sealed since Norman’s initial sampling of the cores and thus were not exposed to the open air at any point during their time in storage.

After selecting my target cores, I arranged my sub-sampling procedure around minimizing the risk of contamination. The simple rule here is to expose the sample to the open air only when entirely necessary, and for the shortest period of time possible, as pollen is a common component of airborne and surface dust and “every opening of the [sample] is an invitation to contamination from the air” (Faegri and Iversen 1989:73). What this meant
functionally was wearing gloves, a lab coat and hair cover, and then using sterile non-porous (in this case plastic) instruments to transfer 2 cc soil sub-samples directly to sterile graduated vials and capping these immediately.

During the pollen concentration procedures, contamination remained a paramount concern (though working under a fume hood helped reduce the risk of pollen settling out of the air and into an open vial). In the section dedicated to pollen concentration I will note where special care was taken to prevent contamination of the samples during processing.

Subsampling

My focus in this research concerns both externally driven – though culturally filtered – environmental change, and the ‘on-site’ signatures of occupational history at Crystal River. I selected three cores (out of five processed) that individually displayed good preservation, and together appeared most appropriate for addressing my research questions. To directly investigate occupational history and ‘on-site’ cultural (subsistence and technological) processes I selected Core 11, taken in the western midden. This core exhibited well-differentiated stratigraphy paralleling the pattern observed in the Trench 1 excavation, enabling me to tie my analysis into the CREVAP chronometric dating program (see Pluckhahn et al. 2015). To investigate environmental change more directly I sub-sampled two cores taken from wetland areas adjacent to the site. Core 48 was taken from the marsh area that buffers the southwestern section of the mound center from the riverfront. Core 55 was taken from a swampy hydric hammock bordering the northeast section of the site. I chose these cores because their stratigraphy appears less directly anthropogenic, or at least does not appear directly associated with habitation, mounding, or refuse deposition. These cores are also positioned well for tracking the proximity of the riverfront (i.e. tidal range) relative to the site through time; further, as wetland deposits, these
cores should contain high-sensitivity microbotanical and silicate markers for various ecological parameters (e.g. salinity, hydroperiod, elevation, climatic considerations, etc.).

For each strata identified and sampled by Norman (2014) from Cores 11, 48, and 55, I collected a 2 cm$^3$ subsample of sediment for pollen concentration and analysis. It is important to note that palynological samples are not typically taken stratigraphically; instead, they are usually taken at close systematic intervals along the length of the core. The stratigraphic sampling (i.e. Norman 2014) does limit my analysis because each strata, irrespective of its depth, is represented here by a single sample, and there is no way to look at palynological variation within large strata. However, the stratigraphic sampling did keep my total sample count manageable, and does enable a straight forward comparison of pollen samples to the interpretation of the materials, stratigraphy, and chronology from Trench 1.

Because my analysis is based in the relative (percentage) abundance of fossil pollen and not ‘absolute’ pollen calculations (extrapolations), high-precision volumetric control over subsampling was not necessary (Faegri and Iversen 1989:72-75). However, I did measure each subsample volume accurately to 2 cm$^3$ in the interest of simplifying the chemical digestion procedure and retaining the ability to informally compare total pollen, phytolith, and sponge spicule counts across samples.

*Pollen Concentration*

After selecting and collecting sub-samples, I transported them to the Laboratory for Paleoecological and Botanical Research at the University of South Florida, St. Petersburg, where I used chemical and mechanical lab techniques to prepare the samples for microscopic analysis. This process concentrates pollen, spores, and other microfossils in the sample via the removal of ‘extraneous matter’ including: other organic particles, humic acids, calcium carbonate, coarse
particles, siliceous matter, cellulose, and fine insoluble particles (Faegri and Iversen 1989:75-81). Below I describe my process for removing extraneous matter and slide mounting; it is important to note (especially for those interested in replicating the methods used here) that the procedure varied slightly with the nature of each sediment sample, mostly in the variable repeating of certain steps and the controlling reaction times. The lab procedure I used was largely adapted from chapter five of Faegri and Iversen’s (1989:69-89) seminal pollen analysis manual.

First, I designated lab sample numbers to each of the soil samples to be processed and created a simple log sheet with a check-box for each procedure step. It was crucial to label the test tubes in several places with the lab sample number, as many of the chemicals involved in the processing easily remove permanent marker (and adhesives). I set up two centrifuges to run at 3000 rpm for 3 minutes; this setting was utilized throughout the process for centrifuging. I placed a mini-vortexer (a rotating plate that facilitates controlled mixing in the test tube) in the fume hood, however the speed required for different steps in the process was quite variable. The small hot water bath required for several steps below was set up in the fume hood and brought to 100 °C, the temperature required for various steps throughout the process. I processed the samples in batches of 8. Each batch required about 8 hours of consistent work and attention. Below I describe the concentration procedure. I have left out specific volumes of reagents, timing considerations, and some other details in the interest of brevity; please see the lab procedure in the appendix for these details (Appendix A).

Deflocculation is essential for breaking up small clumps of sediment and organic material and bringing all of the sample material into solution. This way no pollen is lost with the removal of coarse particles, and the entire sample is exposed to further chemical and mechanical treatment. Each sample was washed with deionized water (hereafter “DI water”), vortexed,
centrifuged, and then decanted. I then added a 5 percent potassium hydroxide (KOH) solution, vortexed, and placed the tubes in the hot water bath before centrifuging and decanting. I next washed the samples in DI water, vortexed, centrifuged, and decanted. This last (washing) step was repeated an average of five to six times for each sample, until the supernatant was clear following centrifuging.

Sieving at this early stage was done to remove coarse particles including sand and large extraneous organics. I suspended each sample in warm 5 percent KOH solution, and then sieved the samples through 125 micron (um) nylon mesh via DI water pressure into clean, labeled 50 ml test tubes. I then centrifuged and decanted the samples.

*Removal of Calcium Carbonate (CaCO\textsubscript{3})* required treatment with hydrochloric acid (HCl). I added 10 percent HCl solution to each sample, using ethyl alcohol (ETOH) to control effervescence. I then placed the samples in the hot water bath to speed the reaction before centrifuging and decanting.

Heavy liquid separation was essential for the removal of silt and clay particles, which may be of similar size to pollen grains but differ in mass. Many palynologists use hydrofluoric (HF) acid to remove small particles from their samples; but because of the safety concerns and bureaucratic barriers surrounding the use of HF, I chose heavy liquid separation as an alternative (and generally equally-effective) method.

I dispersed each sample into a saturated solution of zinc chloride (ZnCl\textsubscript{2}), stirred well, and then centrifuged. This treatment concentrates the dense mineral components in the base of the tube and allows the pollen grains and other microfossils to remain in solution; as such, the supernatant (i.e. the pollen sample) was decanted into a sterile 140 ml beaker and washed with DI water. A few drops of 10 percent HCl were added here to prevent the formation of Zn(OH)\textsubscript{2} –
a white solid that is nearly impossible to remove without destroying the pollen. I then transferred the supernatant-DI water solution to 50 ml tubes and centrifuged. Most often, the remaining organics in the sample were not fully compressed to the base of the tube after the initial centrifuging (because of the residual high density of the solution). In these cases I pipetted off the supernatant portion of the solution (above the pollen grains), added DI water to bring down the solution density and allow the pollen to sink, and centrifuged again. Occasionally, samples required repeated ‘pipette decanting’ and DI water addition before the sample would settle to the base of the test tube.

Acetolysis removes cellulose from the sample, and dyes the pollen grains a useful and pleasant burnt umber color. Working under the fume hood, I washed the samples in glacial acetic acid, then vortexed, centrifuged, and decanted into a designated waste container. I then added a solution of acetic anhydride and sulfuric acid to each sample and placed the tubes in the hot water bath for three minutes. In this step precautions were taken to avoid contact between the sample and the water, as this contact would create an undesirable highly-exothermic reaction. Following the heat treatment, the samples were centrifuged and decanted into a designated waste container. I washed the samples again in glacial acetic acid, vortexed, centrifuged, and decanted to remove any residual anhydride/sulfuric acid solution and prepare them for fine sieving.

Sieving at this stage was necessary to remove very fine clay particles. I suspended the samples in warm percent 5 KOH, and then sieved them through 7 um nylon mesh using DI water pressure and vibration. In this step, the sample caught by the mesh contains the pollen grains while the fine clay particles are washed through. I washed the pollen sample off the mesh and into sterile 50ml tubes, centrifuged, and decanted.
Dehydration removes the water from the samples, enabling me to replace it with silicone oil for preservation and mounting on microscope slides. Working under the fume hood, I added tertiary butyl alcohol (TBA), vortexed, centrifuged, and decanted into a designated waste container. This process was repeated after transferring the sample to half-dram glass vials. After a final decanting (via pipette), I suspended the pollen samples in silicone oil and let them sit partially uncapped in the fume hood overnight to allow full evaporation of residual TBA.

Mounting of the sample onto a microscope slide was the final step in preparing samples for analysis. I prepared ‘wet’ slide mounts of my samples in silicone oil with only the corners of the coverslips sealed; this way the individual grains could be turned and inspected from all sides during analysis by pressing gently on the cover slip with a pencil tip.

*Reference Sample Preparation*

While it is possible to identify fossil pollen grains from published keys and images – especially given the extensive online resources developed by various institutions (e.g., the University of Arizona Catalog of Internet Pollen and Spore Images [Davis 2011]) – it remains difficult to be certain in identification without consulting reference samples. With the aid of Dr. Thomas Whitmore, along with the assistance of staff and volunteers at the USFSP Teaching Herbarium, I obtained modern pollen samples (i.e. flower anthers) from various local flora. Fresh pollen cannot simply be mounted ‘as is’ for inspection; it must be digested in the wet lab to remove waxy coatings, pigments, and various other organic compounds that obscure the structural morphology of the pollen grains. The process for preparing fresh reference samples is quite similar to that used for soil samples, and proceeds through deflocculation, sieving (125 um mesh), removal of CaCO$_3$, acetolysis, and dehydration (see Appendix B for a detailed procedure). Notably, heavy liquid separation and fine sieving (7 um mesh) are not necessary for
reference material. Microscope slide mounting is slightly different from the core samples in that
the entire cover slip is sealed so as not to allow the oil (and pollen) to leak or dry out during
long-term storage. These reference samples will now serve as a ‘permanent’ resource for the
USFSP Teaching Herbarium and Laboratory for Paleoeccological and Botanical research.

Microscopy Procedures

Pollen grains are microscopic, measuring generally between 10 and 120 microns. The
critical magnification range needed for identification is between 300x and 1000x, and the
comfortable magnification for running most analysis is approximately 400x (Faegri and Iversen

I surveyed transects across each microscope slide, identifying and counting all observed
pollen grains as I moved the slide under the microscope via the mechanical stage. Each transect
covered approximately 200 um of slide width, with transects spaced 50 um or so apart to prevent
double counting of any palynomorphs. I sketched each novel pollen taxa that I encountered in a
notebook, made tally counts, morphological notes, and taxonomic identifications adjacent to the
sketches. This way each transect was well documented with count data and individual grains can
be re-located for review. Further, my microscope is equipped with a digital camera, so in
addition to sketches I took photographs of many encountered taxa and unknown grains for later
cross checking and verification with reference samples.

Taxonomic Identifications

Identifying pollen grains requires assessing various morphological traits for comparison
to published identification keys, published images, and reference samples. The most
taxonomically diagnostic traits are furrows and pores in the exine surface, but surface texture,
size, and shape are also important indicators. As briefly described in Chapter Two, the first steps in identification involve noting the size, shape, and pore/furrow typology of the grain. For all but the most obvious taxa, the pore(s) and/or furrow(s) and other features then must be measured along various dimensions for comparison to published identification keys and reference samples. Two published resources were exceptionally helpful for getting started in the identification process. Willard and colleagues (2004) *Atlas of Pollen and Spores of the Florida Everglades* features high-quality SEM images of pollen grains along with useful descriptions and average measurement ranges for each pictured taxa. Ronald Kapp’s (1969) *How to Know Pollen and Spores* features a broadly-ranging North American pollen identification key with select illustrations, descriptions, and measurements. These resources, along with family-specific journal publications (e.g. Kurmann 1992; 1994) and comparisons with modern reference samples, enabled me to confidently make identifications. Most often I narrowed the identifications to the genus level, but occasionally was able to identify grains down to specific species.

*The Pollen Count*

In each sample I identified and counted several hundred individual palynomorphs. This count included pollen grains as well as palm (Areceae) phytoliths and ‘intact’ sponge spicules (>50 um in length). I then entered the raw count data into excel worksheets, calculated relative percentages of each taxa, and imported these data into Tilia 2.0.4.1—a software program that plots and analyzes paleoecological data (©1991-2015 Eric Grimm). Tilia 2.0.4.1 enabled me to produce a pollen diagram for each core, which contain multiple graphs displaying the relative percent composition of pollen taxa in each stratigraphic sample. I also utilized this software to run a Constrained Incremental Sum of Squares (CONISS) cluster analysis (Grimm 1987) on
Cores 11 and 55 and display the results via a dendrogram adjacent to the diagrams (see Chapter 5). The CONISS utilizes an incremental sum of squares approach, but takes account of *a priori* stratigraphic superpositioning so as to preference (to some degree) the grouping of adjacent sediment samples. The CONISS here includes square root transformations and utilizes Edwards and Cavalli-Sforza’s Chord Distance as a dissimilarity coefficient, which treats populations as points within a D-dimensional Euclidean space. This coefficient is commonly used in both genetic studies and in stratigraphic palynology (e.g. Hansen et al. 2001).
CHAPTER FIVE: RESULTS

Core 11: Feature B

Core 11 was taken in three sections by the CREVAP field crew on May 23rd of 2011 with a GeoProbe hydraulic coring device. The core was taken in the southwestern section of Feature B, in the best preserved and highest elevation portion of the midden ridge (E1020.099/N819.885).

Stratigraphy

Figure 5.1 displays photographs of the three GeoProbe sections that make up Core 11 along with: the stratigraphy sampled by Norman (2014), soil grain size sorting data, and soil color descriptions. This figure and each of the core photograph figures to follow were created by Sean Norman (Norman 2014).

An immediately apparent sampling issue must be mentioned here before proceeding. The Core 11 stratigraphy is considerably more complex than demarcated and sampled by Norman. Indeed, single samples (recognized strata) seem to contain multiple actual soil strata; this is perhaps most clear in Norman’s Stratum 7, which contains a minimum of three distinct depositional layers that, ideally, would have been sampled separately. This sampling issue reflects, firstly, how different methodological approaches are predisposed to different sampling strategies, and secondly, the exceptional difficulty encountered when working with soil cores taken in anthropogenic deposits – especially those composed principally of shell and sand.
Figure 5.1. Photographs of Core 11 with Sampled Strata and Sediment Descriptions
The merging of apparently distinct midden strata may well have resulted from Norman’s attempt to negotiate the possible presence of (variably voluminous) slough at the top and bottom of each core section. Such as it is, my analyses represent the stratigraphy as originally sampled, and I will refer to the Core 11 samples as numbered by Norman (2014).

The stratigraphy of Core 11 is remarkable, and demonstrates a clear, alternating pattern of organic-rich ‘black earth’ soil formation followed by the relatively rapid deposition of dense, mollusk-shell layers. This patterned midden deposition extends more than a meter below the ground surface (to 108 cm below surface [cmbs], not accounting for the soil compaction inherent in this type of core sampling). Below the midden strata lies 40 cm of relatively sterile medium-coarse sand; and at the base of the core, below the sand and just above the limestone substrate, sits a thin stratum containing a sandy clay loam with eroding parent material and, unexpectedly, a dark, humic, soil-like component.

*Chronology*

The stratigraphy in Core 11 corresponds quite well with the pattern encountered in Trench 1 (excavated adjacent to Core 11) and this correspondence enables me to apply Pluckhahn and colleagues’ (2015) Bayesian chronological phase model to the core strata analyzed here. A soil carbon sample (sample # 8CI1SS515C; UGAMS # 26154) from Stratum 11 (158 – 160 cmbs)---which sits directly atop the limestone substrate---yielded an uncalibrated radiocarbon age of 4030 ± 25 B.P. (2620–2475 cal B.C. at 2σ) (Table 5.9). The sand strata lying atop this thin pre-occupation soil and below the earliest midden deposits remain undated, but were clearly deposited sometime during the last two millennia B.C. before people began laying down the initial midden materials. The earliest midden deposits, grouped by Norman (2014) into Stratum 7 (72–108 cmbs), match well with the dates from Trench 1 strata associated with Phase
which is modeled at ca. cal A.D. 65 to 265 at 95 percent confidence intervals. Later midden deposits, divided into Strata 6 (58-72 cmbs), 5 (47-58 cmbs), and 4 (37-47 cmbs), are best associated with Trench 1 strata dated to Phase 2 — modeled to ca. cal A.D. 221 to 554 at 95 percent confidence intervals. The upper strata of Core 11, divided here into Stratum 3 (24-37 cmbs), Stratum 2 (6-24 cmbs), and Stratum 1 (0-6 cmbs), fall into Phase 3—modeled to ca. cal A.D. 478 to 809 at 95 percent confidence intervals. Phase 4 deposits are not present in Trench 1; and because of the close proximity and nearly congruent stratigraphy of Core 11 it is quite likely that these deposits are also absent here. Notably, Phase 4 and later deposits are present in both wetland cores analyzed for this study.

**Preservation**

The organic-rich midden samples in Core 11 (Strata 1-7) displayed generally good pollen preservation, and I reached my desired count of between 100 and 300 palynomorphs in each sample without having to prepare secondary microscope slides. As expected, the ‘sterile’ sand strata (Strata 8, 9 and 10) below the initial midden displayed very poor pollen preservation (a few grains or spicules per slide), and thus have been excluded from the pollen diagrams — appearing as an area with no data. The thin organic-rich deposit at the base of Core 11 below the ‘sterile’ sand strata (Stratum 11) demonstrated good pollen preservation and yielded a strong total palynomorph count (n=215).

**Core 11: Palynological Data**

Tables 5.1 and 5.2 display raw palynomorph count data and percent composition data respectively for the Core 11 samples. Total palynomorph counts (identified pollen grains and palm phytoliths) in Core 11 ranged between 141 (Stratum 3) and 475 (Stratum 4), with an average count of 255.
Table 5.1. Raw Count Data for Core 11

<table>
<thead>
<tr>
<th>Stratum</th>
<th>Depth (cm)</th>
<th>Arboreal Taxa</th>
<th>Non-Arboreal Obligate Wetland Taxa</th>
<th>Non-Arboreal Taxa</th>
<th>Total Identified</th>
<th>Unidentified</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0-6</td>
<td>6-24</td>
<td>24-37</td>
<td>37-47</td>
<td>47-58</td>
<td>58-72</td>
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<tr>
<td></td>
<td>72-108</td>
<td>108-112</td>
<td>112-150</td>
<td>150-158</td>
<td>158-160</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
</tr>
<tr>
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<td>8</td>
<td>9</td>
<td>10</td>
<td>11</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pinus spp.</td>
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<td>5</td>
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<td>3</td>
<td>0</td>
<td>1</td>
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<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Ulmaceae</td>
<td>0</td>
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<td>0</td>
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<td>0</td>
</tr>
<tr>
<td>Juniperus silicicola</td>
<td>3</td>
<td>4</td>
<td>2</td>
<td>6</td>
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<td>0</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>Morus rubra</td>
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<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Palmae (phytoliths)</td>
<td>111</td>
<td>115</td>
<td>108</td>
<td>394</td>
<td>175</td>
<td>128</td>
</tr>
<tr>
<td>Total Asters</td>
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<td>1</td>
<td>1</td>
<td>4</td>
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<td>0</td>
</tr>
<tr>
<td>Mimosa spp.</td>
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<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Boehmeria cylindrica</td>
<td>4</td>
<td>4</td>
<td>24</td>
<td>48</td>
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<td>20</td>
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<td>Brassicaceae</td>
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<td>0</td>
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<td>0</td>
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<tr>
<td>Solanum americanum</td>
<td>2</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Cheno-Am</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Commelina spp.</td>
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<td>1</td>
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<td>0</td>
<td>1</td>
<td>0</td>
</tr>
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<td>12</td>
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</tr>
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<td>0</td>
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<td>0</td>
</tr>
<tr>
<td>Sagittaria spp.</td>
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<td>1</td>
<td>0</td>
<td>9</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Saururus cernuus</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>3</td>
<td>8</td>
</tr>
<tr>
<td>Pontederia cordata</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Typha spp.</td>
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<td>0</td>
<td>1</td>
<td>3</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Cyperus spp.</td>
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<td>20</td>
<td>2</td>
<td>8</td>
<td>13</td>
<td>6</td>
</tr>
<tr>
<td>Rhynchospora spp.</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Eleocharis spp.</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Cladium mariscus</td>
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<td>29</td>
<td>4</td>
<td>8</td>
<td>15</td>
<td>8</td>
</tr>
<tr>
<td>Thelypteris kunthii</td>
<td>3</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Polygonum spp.</td>
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<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Polypondiaceae</td>
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<td>0</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Blechnum spp.</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Total Ferns</td>
<td>3</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>Total Identified</td>
<td>163</td>
<td>171</td>
<td>141</td>
<td>475</td>
<td>284</td>
<td>188</td>
</tr>
<tr>
<td>Unidentified</td>
<td>12</td>
<td>15</td>
<td>9</td>
<td>25</td>
<td>16</td>
<td>10</td>
</tr>
</tbody>
</table>

The pollen diagram for Core 11 (Figure 5.2) displays percent composition data for the 20 most salient (and most frequent) taxa, and shows the stratigraphic chronology extrapolated from Trench 1. The graphs are organized within the diagram to bring out temporal patterns in relative species composition, which are apparent throughout the core. Indeed, each taxon shows substantial stratigraphic variation in relative abundance and no taxon remains consistently
dominant throughout the core (though palm phytoliths dominate the microbotanical assemblage in each of the midden strata).

Table 5.2. Percent Species Composition Data for Core 11

<table>
<thead>
<tr>
<th>Stratum</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
</tr>
</thead>
<tbody>
<tr>
<td>Depth (cm)</td>
<td>0-6</td>
<td>6-24</td>
<td>24-37</td>
<td>37-47</td>
<td>47-58</td>
<td>58-72</td>
<td>72-108</td>
<td>108-112</td>
<td>112-150</td>
<td>150-158</td>
<td>158-160</td>
</tr>
<tr>
<td>Pinus spp.</td>
<td>.6</td>
<td>.6</td>
<td>.6</td>
<td>.6</td>
<td>.6</td>
<td>.6</td>
<td>.6</td>
<td>.6</td>
<td>.6</td>
<td>.6</td>
<td>.6</td>
</tr>
<tr>
<td>Carya spp.</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Magnolia spp.</td>
<td>.6</td>
<td>.6</td>
<td>.6</td>
<td>.6</td>
<td>.6</td>
<td>.6</td>
<td>.6</td>
<td>.6</td>
<td>.6</td>
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<td>.6</td>
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<tr>
<td>Ulmaceae</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Juniperus silicicola</td>
<td>1.8</td>
<td>2.3</td>
<td>1.4</td>
<td>1.3</td>
<td>0</td>
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<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Morus rubra</td>
<td>.6</td>
<td>.6</td>
<td>.6</td>
<td>.6</td>
<td>.6</td>
<td>.6</td>
<td>.6</td>
<td>.6</td>
<td>.6</td>
<td>.6</td>
<td>.6</td>
</tr>
<tr>
<td>Palmae (phytoliths)</td>
<td>No Data</td>
<td>No Data</td>
<td>No Data</td>
<td>No Data</td>
<td>No Data</td>
<td>No Data</td>
<td>No Data</td>
<td>No Data</td>
<td>No Data</td>
<td>No Data</td>
<td>No Data</td>
</tr>
</tbody>
</table>

Figure 5.3 displays a Constrained Incremental Sum of Squares (CONISS) cluster analysis to the right of the percent composition graphs. The CONISS groups the stratigraphic sample
assemblages and facilitates the identification and demarcation of five distinct ecological ‘zones’ in the core (not counting the Sand Zone). These five zones appear in Figure 5.2, with each categorized by the dominant ecological regime suggested by palynological analysis.

The data from Zones 1-4 in Core 11 emanate from midden deposits, and thus reflect both elements of the ‘pollen rain’ (environmental and socioenvironmental signatures) and direct anthropogenic deposition of microbotanical material. In these samples I primarily take the assemblages as environmental/socioenvironmental signatures, and will address the potential influence of direct anthropogenic deposition of palynomorphs in the following chapter.

Table 5.3. Total Pollen and Spicule Counts and Sponge/Pollen Ratios for Core 11

<table>
<thead>
<tr>
<th>Locus</th>
<th>Depth (cm)</th>
<th>Total Pollen Count</th>
<th>Sponge Spicule Count</th>
<th>Sponge/Total Pollen</th>
<th>Ecological Zone</th>
</tr>
</thead>
<tbody>
<tr>
<td>Core 11</td>
<td>0-6</td>
<td>163</td>
<td>29</td>
<td>.17</td>
<td>Zone 1</td>
</tr>
<tr>
<td></td>
<td>6-24</td>
<td>171</td>
<td>32</td>
<td>.18</td>
<td></td>
</tr>
<tr>
<td></td>
<td>24-37</td>
<td>141</td>
<td>142</td>
<td>1.00</td>
<td>Zone 2</td>
</tr>
<tr>
<td></td>
<td>37-47</td>
<td>475</td>
<td>387</td>
<td>.81</td>
<td></td>
</tr>
<tr>
<td></td>
<td>47-58</td>
<td>284</td>
<td>215</td>
<td>.75</td>
<td>Zone 3</td>
</tr>
<tr>
<td></td>
<td>58-72</td>
<td>188</td>
<td>240</td>
<td>.27</td>
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</tr>
<tr>
<td></td>
<td>72-108</td>
<td>324</td>
<td>172</td>
<td>.53</td>
<td>Zone 4</td>
</tr>
<tr>
<td></td>
<td>108-112</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>Sand</td>
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<td></td>
<td>112-150</td>
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<td>150-158</td>
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<tr>
<td></td>
<td>158-160</td>
<td>215</td>
<td>2</td>
<td>.01</td>
<td>Zone 5</td>
</tr>
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</table>
Core 11: Zone 5. Guided by the CONISS analysis and my review of the species composition data, I separated Stratum 11 (159-160 cmbs) into a unique ecological zone. Notably, the sand strata were excluded from the CONISS, so the distinction of this zone is not likely to be an artifact of the a priori stratigraphic constraining function of the cluster analysis. The sample contains very little arboreal pollen (limited to 2.3 percent *Juniperus silicicola* and single grains of *Magnolia* spp. and *Ulmaceae*). The assemblage of non-arboreal and non-arboreal obligate wetland taxa is dominated by *Boehmeria cylindrica* (55.3 percent) and *Typha* spp. (25.6 percent), with *Eleocharis* spp. (7.4 percent), *Sagittaria* spp. (3.7 percent), *Saururus cernuus* (3.2 percent), and *Cyperus* spp. (.9 percent) also present.

This assemblage suggests that this early deposit formed along the shoreward side of freshwater marshes bordering the river. The freshwater regime is suggested by the dominance of the freshwater-dependent and generalist marsh taxa listed above; a shoreward position is likely because of the abundance of *Boehmeria c.*—a facultative wetland pioneer forb that tolerates flooding but not perennial deep-water conditions. Additionally, this stratum is the only viable Core 11 sample without *Sabal palmetto* phytoliths, which dominate the microbotanical assemblage in the midden strata above. Further, only 2 sponge spicules were counted in the sample from Stratum 11 (see Table 5.3) this count is dramatically low when compared to the average for Core 11 samples (169.6 spicules) (excluding zero values from sterile sand strata), or even the average count for all analyzed samples (107.7 spicules).

Core 11: Sand Zone. The Sand Zone in Core 11 includes Strata 8 (108–112 cmbs), 9 (112–150 cmbs), and 10 (150-158 cmbs). As expected, these strata yielded almost no identifiable pollen grains, phytoliths, or sponge spicules.
Figure 5.2. Core 11 Pollen Diagram with Phase Chronology and Ecological Zones
Figure 5.3. Core 11 Pollen Diagram with Phase Chronology and CONISS
This poor preservation most likely resulted from the abundance of coarse sand grains in these strata, which slice and grind up both pollen grains and silicate indicators – making their remains too fragmentary to identify. Given the nature of local silicilastic sediment supply and transportation processes (see Goodbred and Hine 1995; Leonard et al. 1995) it is very likely that this sub-midden levee-like sand deposit resulted from one or more storm surge events.

Core 11: Zone 4. I also grouped Stratum 7 (72-108 cmbs) into a unique zone (Zone 4), and indeed this initial midden layer exhibits a pollen assemblage not seen elsewhere in the core sequence. *Juniperus s.* is relatively abundant in this sample (8.0 percent) and is joined by a single *Pinus spp.* grain. Southern red cedar trees (*Juniperus s.*) tend to dominate relatively haline niches on the hammocks of the Crystal River/Salt River system because they tolerate relatively high-salinity conditions, indeed only the cabbage palm (*Sabal palmetto*) (phytoliths at 64.5 percent) is more salt resistant (Vince et al. 1989; Williams et al. 1999). The non-arboreal and non-arboreal obligate wetland taxa in Zone 4 are dominated by *Boehmeria c.* (21.0 percent), and sedges (*Cladium m.*, *Rhynchospora spp.*, and *Cyperus spp.*) (3.1 percent), but also include *Typha spp.* (1.5 percent).

Taken together this assemblage suggests that an environmental regime shift occurred between Stratums 11 and 7 (as also evidenced by the 40 cm of sand deposition). This transition most likely saw an inland expansion of a tidally influenced, brackish marsh system, enabling the proliferation of southern red cedar, cabbage palm, and oligohaline sedges (i.e. *Cladium m.* and *Cyperus spp.*); this brackish marsh expansion is also likely the best explanation for the absence of the least salt-tolerant (freshwater) wetland forb taxa (i.e. *Sagittaria spp.*, and *Saururus c.*) that were previously abundant in Zone 5. The decrease in cedar, along with the concurrent appearance of coastal plain willow (*Salix c.*), hickory (*Carya spp.*), and *Magnolia spp.* suggest
that previously cedar-dominated haline niches opened up to support these new arboreal taxa with relatively low salt tolerance. The presence of coastal plain willow is particularly interesting, as this species thrives only in freshwater wetland soils and favors disturbed locales. Palm phytoliths remain the dominant microbotanical component in both Stratum 5 (61.6 percent) and Stratum 6 (68.1 percent)

**Core 11: Zone 3.** The non-arboreal and obligate wetland non-arboreal taxa in Zone 3 also suggest increased freshwater input, along with warm climate and increased local disturbance. The non-arboreal assemblage diversified in Zone 3 to include various warmth/precipitation-loving, disturbance-marker taxa, including: *Smilax spp.* (4.2 percent), *Amaranthaceae-Chenopodium* (.5 percent), *Solanum americanum* (.5 percent), *Brassicaceae* (.3 percent), *Commelina spp.* (.5 percent), and *Poaceae* grasses (.5 percent). Among the obligate wetland forbs *Saururus cernuus* becomes abundant, especially in Stratum 6 (4.2 percent), while *Pontederia cordata* (1.1 percent), *Rhynchospora spp.* (.5 percent), and *Sagittaria spp.* (.3-1.1 percent) are also present. The presence of the distinctly non-haline *Saururus c.* and *Pontederia c.*, in particular, indicates that flooded/ponded freshwater wetland areas were locally present and maintained some separation from the tidally-influenced brackish river water. Indeed, the presence of generalist sedges *Eleocharis spp.* (.5-.7 percent) and *Cyperus spp.* (3.1-4.6 percent), along with *Typha* (1.8-2.6 percent) suggest that marsh plants immediately bordering the river likely still had to tolerate oligohaline conditions, despite the increased freshwater input and development of freshwater wetlands in more landward locales.

Additionally, sponge spicules abound in Zone 3---both in terms of total spicule count and the spicule/total pollen ratio (Table 5.3). I interpret this mostly as an artifact of human activities
related to subsistence, technology, and mound construction (see Chapter 6) and not an \textit{in situ} paleoenvironmental indicator.

\textbf{Core 11: Zone 2.} Zone 2 contains two strata – Stratum 3 (24-37 cmbs) and Stratum 4 (37-47 cmbs) – that share very similar assemblages; indeed the CONISS analysis suggests that these two samples are the most closely associated/least differentiated of the core. The arboreal pollen assemblage diversity decreased substantially in Zone 2. Cedar (1.3-1.4 percent) increases slightly in abundance from Zone 3, and pine remains present (.6 percent). However, none of the other arboreal taxa present in Zone 3 (\textit{Carya} spp., \textit{Salix} c., \textit{Magnolia} spp.) are represented in Stratum 3 or 4. Palm phytoliths increase in relative abundance, reaching 82.9 percent. Smallspike false nettle (\textit{Boehmeria} c.) continues to dominate the non-arboreal assemblage (10.1-17.0 percent), though its relative abundance is less than found in Zone 3 (10.6-23.9 percent). Notably, Zone 2 is contains no pollen from the warmth/precipitation-loving weedy taxa from Zone 2 (\textit{Brassicaceae}, \textit{Solanum} a., \textit{Chenopodium}, \textit{Smilax}, \textit{Poaceae}). Further, many of the obligate wetland forbs also drop out of the assemblage at the onset of Zone 2, with only \textit{Sagittaria} spp. (1.9 percent), \textit{Typha} (.6-.7 percent), and small percentages of generalist sedges (\textit{Eleocharis} spp. and \textit{Cyperus} spp.) present. Sponge spicules remain prevalent (.8-1.0 spicules/pollen grain) at relative counts similar to Zone 3 (Table 5.3). Taken together, the pollen record in Zone 2 is marked by a reduction in the prevalence of preserved pollen grains (relative to palm phytoliths and sponge spicules), low taxonomic diversity, and the dominance of generalist plants that tolerate relatively wide swings in temperature and precipitation.

\textbf{Core 11: Zone 1.} Zone 1 contains Stratum 1 (0-6 cmbs) and Stratum 2 (6-24 cmbs), the upper two midden strata in Core 11. The assemblage is most closely related to midden samples from Zones 3 and 4, and represents a clear divergence from the conditions in Zone 2. The species
composition in Zone 1 is, as expected, the most similar to the vegetation assemblage currently occupying the Crystal River site and the adjacent wetlands. Cedar increased in abundance to 1.8-2.3 percent, and pine makes up a noteworthy portion of the assemblage (2.9-3.0 percent) for the first time in the core. *Magnolia* *spp.* returned (6.6 percent) after its absence in Zone 2 and red mulberry (*Morus rubra*) pollen appears for the first time in the core (6.6 percent). Palm phytoliths decrease slightly in relative abundance, but remain dominant at 67.1-68.1 percent.

Among the non-arboreal taxa, *Boehmeria c.* decreases to 2.3-2.4 percent and no longer dominates the non-arboreal pollen assemblage. Several of the warmth/precipitation-loving taxa from Zone 3 (Brassicaceae, *Solanum a.*, Cheno-Am) return in Zone 1. The obligate wetland forb assemblage in Zone 1 is dominated by *Cyperus* *spp.* (11.6-11.7 percent) and *Cladium m.* (4.3-4.7 percent), suggesting that brackish marsh (again) became dominant in the river-bank wetlands near the site. Single grains of *Sagittaria* *spp.* and *Saururus c.* speak to the continued presence of these freshwater dependent taxa in local wetlands set back from the influence of brackish river water. Sponge spicules are unusually infrequent in Zone 1 strata (2 spicules/palynomorph) given their abundance in the underlying midden strata.

**Core 48: Southwest Marsh**

Core 48 was taken via Vibracore in the brackish *Typha/Cladium* marsh immediately to the south of Mound K. The core was located about 25 m from the marsh – hammock/midden interface at grid location E341193/N318864).
Stratigraphy

Figure 5.4 displays a photograph of Core 48 and shows the stratigraphy as recognized and sampled by Norman (2014), along with notations of soil grain size sorting and color descriptions. As in Core 11, the stratigraphy in Core 48 appears more complex than recognized, demarcated, and sampled by Norman. Stratum 1 (0-46 cmbs) of Core 48 appears to contain multiple observable soil strata, along with a shell lens, and a root-like disturbance. As this sample has already been collected and homogenized, my analysis represents Stratum 1 as originally sampled (0-46 cmbs).

The soil profile in Core 48 matches the dark brown-to-black peaty-mud facies described at length by Goodbred and colleagues (1998), Hine and colleagues (1988), Hutton (1986), and Wright and colleagues (2005). These deposits---characteristic of the Big Bend coastal region---are formed by the deposition/decomposition of brackish marsh plant tissues (largely Typha spp. and Cladium with occasional stands of Juncus spp.). Stratum 2, the basal six centimeters of the soil core, contains a fair quantity of fragmentary shell, small faunal remains, and charred plant material in a peaty-mud matrix (also noted by Delgado 2016; Norman 2014). This stratum has no good ‘natural’ correlate in the geological/petrological literature for the region and very likely formed via direct and/or indirect deposition of midden materials. A coring survey by Brent Weisman, Barbara Purdy, Ray MaGee, and Erica Hill in August of 1993 focused on the wetland areas surrounding Mound A (Anonymous 1995). In an auger core taken in the marshes west of Mound A the team encountered midden deposits extending between 116 and 220 cmbs, suggesting that midden deposits extend well below those encountered and analyzed for this research. Correcting for the compaction inherent in the Vibracore sampling utilized by the
CREVAP crew, the midden strata at the base of Core 48 likely does rest below about a meter of marsh deposits (as encountered by Weisman, Purdy, MaGee, and Hill in 1993).

**Chronology**

A charcoal sample from Stratum 2 (sample # 8CI11153C; UGAMS # 20935) yielded an uncalibrated radiocarbon age of 1380 ± 20 B.P. (Table 5.9). The calibrated date range of cal A.D. 620 to 680 (2σ) falls within Phase 3 of occupation at Crystal River and aligns temporally with the Buck Key Low Stand noted in Southwest Florida and the broader Vandal Minimum climatic episode (Gunn 1994:17; Stapor et al. 1991:872; Tanner 1993; Walker et al. 1994; 1995). The midden deposits likely extending below Stratum 2 (encountered by Weisman, Purdy, MaGee, and Hill) may date to earlier phases of occupation at Crystal River; however, until new cores are pulled and radiocarbon samples are analyzed, the best chronology we have is for the terminus of midden deposition in the Core 48 area around cal A.D. 620-680. The original sampling strategy used to collect stratigraphic samples from Core 48 makes running radiocarbon samples on Stratum 1 an all-but-useless notion; however, the basal date on Stratum 2 provides a *terminus post quem* for the incipient development of the brown/black peaty-mud that makes up the upper 46 cm of the core. The bulk of this thick marsh peat formation quite likely took place with renewed sea-level transgression during the ninth and tenth centuries A.D.

**Preservation**

The organic-rich marsh peat (Stratum 1) and shell-rich, midden-like organic mud (Stratum 2) of Core 48 exhibited good preservation of both pollen grains and sponge spicules. As in Core 11, I counted to my targeted count range (to 200 palynomorphs in Stratum 1 and to 118 in Stratum 2) without having to mount secondary slides for either sample.
Figure 5.4. Photographs of Core 48 with Sampled Strata and Sediment Descriptions

1: (A) 10YR2/1 black clay loam (30% sand, 33.3% silt, 36.7% clay), rare shell

2: (A2) 10YR3/1 very dark gray sandy clay (46.7% sand, 16.7% silt, 36.7% clay), rare shell
**Core 48: Palynological Data**

Table 5.4 displays the raw pollen-count and percent composition data for the two Core 48 samples. Table 5.5 displays the total spicule counts for each stratigraphic sample along-side the total palynomorph count and shows values for the frequency of spicules relative to the total pollen count. The pollen diagram for Core 48 (Figure 5.5) displays percent composition data for the 19 most salient (and most frequent) taxa. A CONISS cluster analysis, as done for Cores 11 (above) and 55 (below) would be inappropriate here for Core 48 because there are only two samples. However, there are clear differences in species composition between the two samples from Core 48.

**Core 48: Stratum 2.** Stratum 2 (46-52 cmbs) contains a diverse assemblage of arboreal taxa, dominated by cedar (9.3 percent), but also including notable quantities of: wax myrtle (*Myrica cerifera*) (5.1 percent), coastal plain willow (*Salix c.*) (4.2 percent), and pine (4.2 percent). Interestingly, palm phytoliths make up only 6.8 percent of the assemblage in Stratum 2. Smallspike false nettle (*Boehmeria c.*) pollen (30.5 percent) dominates among the non-arboreal taxa, with Brassicaceae family taxa making up 3.4 percent. The non-arboreal obligate wetland taxa assemblage is particularly interesting, containing: *Cyperus spp.* (7.6 percent), *Sagittaria spp.* (7.6 percent), various ferns (totaling 7.6 percent), *Saururus c.* (4.2 percent), and *Typha spp.* (1.7 percent). Sponge Spicules were present in Stratum 2 (n=57), occurring at a rate of .5 spicules/palynomorph; notably this is about half the rate at which spicules were encountered in Zones 2 and 3 of Core 11.

The assemblage contains a clear oligohaline signature and suggests the local proliferation of transitional freshwater-oligohaline river-bank marshes (*Cyperus spp., Typha spp., Boehmeria c.*) with cedar, wax myrtle, oaks, and palms along the hammock-marsh interface.
The abundant freshwater-dependent taxa in the assemblage (e.g. *Sagittaria* spp., *Saururus cernuus*, *Salix cernuus*) most likely represent the local presence of freshwater wetlands set back some distance from the river bank. As with Core 11, the presence of midden materials in Stratum 2 opens the interpretation of this palynological data to more direct sociocultural processes (discussed in the following chapter).
Table 5.5. Total Pollen and Sponge Counts and Sponge/Total Pollen Ratios for Core 48

<table>
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<tr>
<th>Locus</th>
<th>Depth (cm)</th>
<th>Total Pollen Count</th>
<th>Sponge Spicule Count</th>
<th>Sponge/Total Pollen</th>
<th>Ecological Zone</th>
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<td>89</td>
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<tr>
<td></td>
<td>46-52</td>
<td>118</td>
<td>57</td>
<td>.483</td>
<td></td>
</tr>
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</table>

**Core 48: Stratum 1.** In Stratum 1 (46–52 cmbs) the arboreal pollen assemblage shifts toward the increased representation of wind pollinated taxa, including *Salix c.* (9.1 percent), *Pinus spp.* (6.6 percent), and *Quercus spp.* (4.6 percent). Palm phytoliths increase substantially to make up 21.8 percent of the assemblage. *Boehmeria c.* decreases dramatically to 6.6 percent while other weedy warmth/precipitation-loving taxa (*Brassicaceae, Solanum a.*, *Poaceae*) become more abundant. The obligate wetland forb assemblage underwent a dramatic transition, with freshwater-dependent taxa being replaced almost entirely in the assemblage by oligohaline marsh plants, particularly *Cladium m.* (15.2 percent). Additionally, *Thelypteris spp.* and *Typha spp.* also increase in abundance.

Taken together, and in comparison to Stratum 2, the pollen data from the upper 46 cm of Core 48 suggest that the area of low-elevation midden was transgressed by tidally-influenced river water sometime after A.D. 620-680, enabling the formation of dense brackish marsh deposits. These deposits trapped pollen from wind-pollenated taxa (e.g. *Salix c.*, *Pinus spp.*, *Quercus spp.*) growing on higher ground, and preserved pollen from the plants growing within the developing marsh peat (i.e. *Cladium m.* and *Typha spp.*).
Figure 5.5. Core 48 Pollen Diagram with Stratum 2 Carbon Date (cal. 2σ)
Core 55: Northeast Hydric Hammock

The 2011 CREVAP field crew took Core 55 via VibraCore in the hydric hammock/freshwater swamp lying to the east of the plaza area and Mounds C-F. The core location is located about 30 m to the east of the plaza, and about 200 m north of the river bank (grid location E341370/N3199076).

Stratigraphy

The stratigraphy of Core 55 (Figure 5.6) is characteristic of freshwater wetlands associated with hydric hammocks, and contains clearly discernable A (humic/mineral soil), E (leeching), and B (accumulation) horizons. Below the accumulation horizon (Stratum 5), Stratum 6 appears to represent an organic-rich buried A (Ab) horizon. It should be noted that this core did not encounter limestone, or even eroded limestone material, and substantial sediment deposits likely underlie Stratum 6.

Preservation

The preservation of microbotanical remains and silicate indicators in Core 55 is quite good, particularly in the organic-rich soil horizons (Strata 1, 2, 3, and 6). Strata 4 and 5 are sandier and yielded lower (but acceptable) total palynomorph counts. As in Cores 11 and 48, I counted to my targeted count range without having to mount secondary slides for any of the samples from Core 55.

Chronology

A soil carbon (charcoal) sample (sample # 8C11SS1176C; UGAMS # 20934) taken from Stratum 6 (44-52 cmbs) of Core 55 yielded a radiocarbon age of 1130 ± 20 B.P. The calibrated range of cal A.D. 880 to 990 at 2σ, falls within Phase 4, the final few centuries of site use at
Crystal River, and corresponds with the return of warm and wet climatic conditions and sea-level rise during the Medieval Warm Period/La Costa High Stand (Pluckhahn et al. 2015; Walker et al. 1995). A soil charcoal sample (sample # 8CI11172C; UGAMS # 24116) from Stratum 2 (12-18 cmbs) was dated to 390 ± 25 radiocarbon years B.P. The calibrated range of cal A.D. 1450 to 1630 at 2σ (Figure 5.10) falls within the Little Ice Age climatic episode (ca. approximately 1400-1800). While there is no evidence for occupation or site use at Crystal River Site beyond ca. A.D. 1100 or so, Strata 2–6 of Core 55 are well positioned (temporally) to address the local socioecological response to the Medieval Optimum/La Costa High as projected for Florida’s Gulf Coast (ca. A.D. 850 to 1450). Further, the palynological data may speak to environmental changes related to the ‘abandonment’ of the site after A.D. 1000 and later ecological responses to the Little Ice Age.

Core 55: Palynological Data

Tables 5.6 and 5.7 display the raw palynomorph count data and percent composition data respectively for Core 55 samples. Total palynomorph counts (identified pollen grains and palm phytoliths) in Core 55 ranged between 114 (Stratum 5) and 334 (Stratum 3), with an average count of 228.

The pollen diagram for Core 55 (Figure 5.7) displays percent composition data for the 18 most salient (and most frequent) taxa, and shows the calendar date ranges for the 2 carbon dated strata. The graphs are organized within the diagram to bring out stratigraphic and temporal patterns in relative species composition, which are apparent throughout the core. Indeed, each taxon shows substantial stratigraphic variation in relative abundance and no taxon remains consistently dominant throughout the core.
Figure 5.6. Photographs of Core 55 with Sampled Strata and Sediment Descriptions

<table>
<thead>
<tr>
<th>Depth (cm)</th>
<th>Description</th>
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</thead>
<tbody>
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<td>Void</td>
</tr>
<tr>
<td>10-20</td>
<td>1: (A) 10YR2/1 black with 7.5YR8/0 white lens sandy clay loam (53.3% sand, 23.3% silt, 23.3% clay)</td>
</tr>
<tr>
<td>20-30</td>
<td>2: (AE) 10YR3/1 very dark gray sandy clay loam (73.3% sand, 3.3% silt, 23.3% clay)</td>
</tr>
<tr>
<td>30-40</td>
<td>3: (AEi) 10YR3/2 very dark grayish brown mottled with 10YR3/1 very dark gray sandy clay loam (66.7% sand, 6.7% silt, 26.7% clay)</td>
</tr>
<tr>
<td>40-50</td>
<td>4: (Ei) 10YR5/2 grayish brown sandy loam (73.3% sand, 6.7% silt, 20% clay)</td>
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<tr>
<td>50-60</td>
<td>5: (B) 10YR3/2 very dark grayish brown sandy loam (80% sand, 6.7% silt, 13.3% clay)</td>
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<tr>
<td>60-70</td>
<td>6: (2A) 10YR2/1 black clay loam (40% sand, 20% silt, 40% clay)</td>
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Table 5.6. Raw Count Data for Core 55

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<tr>
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<td></td>
<td>21</td>
<td>18</td>
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<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Cheno-Am</td>
<td></td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
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<tr>
<td>Commelina spp.</td>
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<td>3</td>
<td>0</td>
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<td>2</td>
<td>2</td>
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<tr>
<td>Non-Arboreal Obligate Wetland Taxa</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
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<td>2</td>
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<td>1</td>
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<td>Pontederia cordata</td>
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<td>4</td>
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<tr>
<td>Total Ferns</td>
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<td>0</td>
<td>0</td>
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<td>8</td>
<td>9</td>
<td>13</td>
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</table>

Figure 5.8 displays the CONISS cluster analysis to the right of the percent composition graphs.

The Core 55 pollen diagram in Figure 5.7 is divided into the three zones determined by the CONISS analysis with each categorized by the dominant ecological regime suggested by palynological analysis.
Table 5.7. Percent Species Composition Data for Core 55

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<tr>
<th></th>
<th>Stratum</th>
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<th></th>
<th></th>
<th></th>
<th></th>
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<tr>
<td></td>
<td>Depth (cm)</td>
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<td>12-18</td>
<td>18-22</td>
<td>22-32</td>
<td>32-44</td>
</tr>
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<td>Arboreal Taxa</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pinus spp.</td>
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<td>6.9</td>
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<tr>
<td>Magnolia spp.</td>
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<tr>
<td>Quercus spp.</td>
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<tr>
<td>Acer rubrum</td>
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<td>Juniperus silicicola</td>
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<td>Morus rubra</td>
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<tr>
<td>Palmae (phytoliths)</td>
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<td>10.5</td>
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<td>Total Asters</td>
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<tr>
<td>Boehmeria cylindrica</td>
<td></td>
<td>9.8</td>
<td>17.8</td>
<td>70.4</td>
<td>76.3</td>
<td>59.6</td>
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<td>1.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Solanum americanum</td>
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<td>5.8</td>
<td>0.3</td>
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<tr>
<td>Cheno-Am</td>
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<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
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<td>Poaceae</td>
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<tr>
<td>Smilax spp.</td>
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<td>0.9</td>
</tr>
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<td>Commelina spp.</td>
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<td>1.0</td>
<td>0.0</td>
<td>0.8</td>
<td>1.7</td>
</tr>
<tr>
<td>Non-Arboreal Obligate Wetland Taxa</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sagittaria spp.</td>
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<td>8.1</td>
<td>16.5</td>
<td>6.9</td>
<td>2.6</td>
</tr>
<tr>
<td>Saururus cernuus</td>
<td></td>
<td>2.9</td>
<td>10.4</td>
<td>0.6</td>
<td>1.5</td>
<td>2.6</td>
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<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Pontederia cordata</td>
<td></td>
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<td>0.3</td>
<td>0.0</td>
<td>1.7</td>
<td>0.0</td>
</tr>
<tr>
<td>Typha spp.</td>
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<td>1.0</td>
<td>0.6</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Cyperus spp.</td>
<td></td>
<td>5.4</td>
<td>1.6</td>
<td>3.9</td>
<td>1.5</td>
<td>4.4</td>
</tr>
<tr>
<td>Rhynchospora spp.</td>
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<td>0.0</td>
<td>0.0</td>
<td>1.7</td>
</tr>
<tr>
<td>Eleocharis spp.</td>
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<td>0.5</td>
<td>0.6</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
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<tr>
<td>Cladium mariscus</td>
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<tr>
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<tr>
<td>Total Ferns</td>
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<td>8.3</td>
<td>3.2</td>
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<td>0.0</td>
<td>0.9</td>
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</table>

Core 55: Zone 3. Zone 3 groups together Stratum 5 (32-44 cmbs) and Stratum 6 (44-52 cmbs); though it should be noted that the CONISS suggests that, of the three zones (each containing two strata), Zone 3 is the ‘loosest’ grouping. Zone 3 contains a relatively scant (yet diverse) arboreal assemblage, limited to Palm phytoliths (10.5-15.6 percent), Juniperus s. (.8-3.5
percent), and small percentages of Quercus spp. (1.1 percent), Salix c. (.9 percent), Morus r. (.9 percent), and Pinus spp. (.8 percent). The non-arboreal assemblage in Zone 3 lacks diversity, and is dominated by the disturbance-loving Boehmeria c. (12.5-59.6 percent), with only minor percentages of Commelina spp. (.8-1.7 percent), Smilax spp. (.9 percent), and Asters (.4 percent). In contrast, the sample contains a variety of abundant obligate wetland forbs, including: Eleocharis spp. (6.1 percent), Cyperus spp. (4.4 percent), Sagittaria spp. (2.6 percent), Saururus c. (2.6 percent), Rhynchospora spp. (1.7 percent), Nymphaea spp. (.9 percent), and ferns (.9-2.0 percent).

The sparse arboreal representation and the dominance of the moderately salt-tolerant sedges Eleocharis spp. and Cyperus spp. suggest that the wetlands adjacent to the site (particularly those nearest the river) experienced substantial tidal influence in the tenth and perhaps eleventh centuries A.D.; however, the abundance of freshwater-dependent marsh plants (i.e. Sagittaria spp., Saururus c., and Pontederia c.) suggest that brackish water only rarely penetrated the wetlands lying landward of the midden ridge (Feature B).

Core 55: Zone 2. Zone 2 contains Stratum 3 (18-22 cmbs) and Stratum 4 (22-32 cmbs). Unlike those above and below, this zone has no definitive date to ground its deposition; however, these strata likely post-date A.D. 930 (Stratum 6) by some centuries and the carbon date on Stratum 2 provides a likely terminus ante quem for the Zone 2 record.

The arboreal assemblage changes very little from the underlying strata, containing Sabal p. phytoliths (1.2-9.9 percent) and Juniperus s. (1.5-5.1 percent), with minor percentages of Magnolia spp. (.3 percent) and Salix c. (.3 percent).
Figure 5.7. Core 55 Pollen Diagram with Carbon Dates (cal. 2σ) and Ecological Zones
Figure 5.8. Core 55 Pollen Diagram with Carbon Dates (cal. 2σ) and CONISS
Boehmeria c. increases in relative (and absolute) abundance (70.3-76.3 percent), continuing to dominate the non-arboreal assemblage, which (like the preceding strata) also contains Smilax spp. (1.5 percent), Commelina spp. (.8 percent), Solanum a. (.3 percent), and Mimosa p. (.3 percent). The obligate wetland species composition changes substantially in Zone 2. The assemblage no longer contains evidence for the presence of Eleocharis spp. or Rhynchospora spp., and suggests a substantial expansion of the Sagittaria spp. (6.9-16.5 percent) population. Saururus c. (.6-1.5 percent) and Pontederia c. (.3 percent) decline, and Typha spp. pollen appears (.6 percent) for the first time in the Core 55 record.

The Zone 2 assemblages---particularly the non-arboreal and obligate wetland components---are characterized by the proliferation of disturbance-loving taxa that are well suited to accommodate swings in temperature and precipitation. The phasing out of the moderately salt-tolerant sedges and their replacement by Boehmeria c. and Sagittaria spp. indicates a reduction in tidal influence and precipitation frequency, and further, supports the cooling of average temperatures expected for the early centuries of the Little Ice Age.

Core 55: Zone 1. Zone 1 in Core 55 includes the upper two strata, Stratum 1 (0-12 cmbs) and Stratum 2 (12-18 cmbs). The CONISS cluster analysis shows Zone 1 as the most distinct zone of the core – an interpretation also apparent after even a cursory review of the species composition data

The arboreal assemblage in considerably more diverse than the remainder of the core, containing: abundant palm phytoliths (33.3-41.5 percent), pine (6.9 percent), cedar (3.6-5.4 percent), Ulmaceae (.32-2.0 percent), Salix c. (1.0-1.3 percent), Morus r. (.5 percent), and oak (.3 percent). The non-arboreal assemblage also increases in diversity to include Solanum a. (5.8-10.3 percent), Brassicaceae (1.0-6.4 percent), Commelina spp. (1.0-4.4 percent), and Mimosa p. (.6
percent) in addition to the much reduced relative percentage (and absolute count) of *Boehmeria* c. (9.8-17.8). The obligate wetland taxa composition does not change dramatically from Zone 2, yet some developments are noteworthy. *Eleocharis* spp. (.5-.6 percent) and *Pontederia* c. (.3-.5 percent)---previously absent---are just barely represented, *Rhynchospora* spp. remains absent, and *Sagittaria* spp. persists (1.0-8.1 percent). *Typha* spp. (1.0 percent) and *Cyperus* (1.6-5.4 percent) increase in relative abundance, and *Saururus* c. (reaching 10.4 percent) and ferns (reaching 8.3 percent) proliferate.

It is clear that during Zone 1 the extant freshwater swamp/hydric hammock community began to develop in the wetland areas to the east of the site. This is evidenced by the robust presence of wetland tree pollen, the decrease in *Boehmeria* c., and the proliferation of *Saururus* c. and ferns, which require at least partial shade.

Table 5.8. Total Pollen and Sponge Counts and Sponge/Pollen Ratios for Core 55

<table>
<thead>
<tr>
<th>Locus</th>
<th>Depth (cm)</th>
<th>Total Pollen Count</th>
<th>Sponge Spicule Count</th>
<th>Sponge/Total Pollen</th>
<th>Ecological Zone</th>
</tr>
</thead>
<tbody>
<tr>
<td>Core 55</td>
<td>0-12</td>
<td>204</td>
<td>23</td>
<td>.1</td>
<td>Zone 1</td>
</tr>
<tr>
<td></td>
<td>12-18</td>
<td>325</td>
<td>80</td>
<td>.2</td>
<td></td>
</tr>
<tr>
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<td>18-22</td>
<td>334</td>
<td>125</td>
<td>.4</td>
<td>Zone 2</td>
</tr>
<tr>
<td></td>
<td>22-32</td>
<td>131</td>
<td>18</td>
<td>.1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>32-44</td>
<td>114</td>
<td>6</td>
<td>.1</td>
<td>Zone 3</td>
</tr>
<tr>
<td></td>
<td>44-52</td>
<td>277</td>
<td>31</td>
<td>.1</td>
<td></td>
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Table 5.9. Radiocarbon Dates from Select Crystal River Site Core Strata

<table>
<thead>
<tr>
<th>Core</th>
<th>Stratum</th>
<th>Sample ID</th>
<th>UGAID</th>
<th>Material</th>
<th>δ13C,‰</th>
<th>Radiocarbon Age (B.P.)</th>
<th>Calibrated Date 2σ (IntCal 13)</th>
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<tbody>
<tr>
<td>48</td>
<td>2</td>
<td>8CI1SS1153C</td>
<td>20935</td>
<td>charcoal</td>
<td>-25.2</td>
<td>1380 ± 20</td>
<td>A.D. 625-671</td>
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<tr>
<td>55</td>
<td>6</td>
<td>8CI1SS1176C</td>
<td>20934</td>
<td>charcoal</td>
<td>-24.9</td>
<td>1130 ± 20</td>
<td>A.D. 878-982</td>
</tr>
<tr>
<td>55</td>
<td>2</td>
<td>8CI1SS1172C</td>
<td>24116</td>
<td>charcoal</td>
<td>-26.8</td>
<td>360 ± 25</td>
<td>A.D. 1452-1634</td>
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<tr>
<td>11</td>
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<td>26154</td>
<td>Soil carbon</td>
<td>-27.7</td>
<td>4030 ± 25</td>
<td>2620-2475 B.C.</td>
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</table>

**Results Summary**

The pedological and palynological records preserved in Cores 11, 48, and 55 together span the temporal range of occupation at Crystal River (ca. A.D. 60 to 1070), and extend into pre-occupation (Core 11) and post-‘abandonment’ periods (Core 55). The results reported here yielded a number of encouraging and intriguing findings. An important result that should not be taken for granted is the recovery of intact fossil pollen assemblages from both wetland and midden deposits at the Crystal River site. As discussed in Chapter Two, this research represents one of the first successful (and reported) archaeopalynological efforts on the Gulf Coast of Florida. Another not-to-be-taken-for-granted result is that the pollen record from Crystal River site is marked by considerable variation over time, enabling me to connect the pollen record to changes in local vegetation communities, and in turn connect these changes to both broad environmental transitions and socioecological processes. Three more particular findings also deserve mention here. First, of the five ecological zones identified in the Core 11 analysis, only Zone 2 bridges two different material-cultural phases (Phases 2 and 3). This correspondence is especially intriguing given the reorganizational sociocultural history of Phase 3 at Crystal River.
and the highly variable, transformational ecological conditions suggested by the Zone 2 pollen assemblage. Further, there is good general temporal correspondence between the vegetation composition changes recorded at Crystal River site and the broad-scale climatic/sea-level changes proposed by researchers working in the Big Bend region and elsewhere. This correspondence enables me to interpret how these broadly documented environmental changes were manifested in the Crystal River system, and how coastal foragers living in the drainage might have experienced them. In closing, I have intentionally refrained from exploring the palynological data reported here from an ethnobotanical perspective. There are indeed many taxa identified in the midden and wetland deposits with well-documented subsistence, technological, medicinal, and metaphysical significance for protohistoric and historic Southeastern Indigenous groups.

In the following chapter I discuss the landscape history of Crystal River site as reconstructed through palynological analysis and my review of relevant archaeological, geological, ecological, and paleoecological literature. In the latter half of the discussion I turn to the ethnobotanical implications of the palynological data from Crystal River site, and pay special attention to plant resources represented here that do not preserve well macroscopically in terrestrial contexts and thus are not typically recovered in archaeobotanical samples.
CHAPTER SIX: INTERPRETATION AND DISCUSSION

Crystal River ca. A.D. 1-1500: A Landscape in Flux

The pollen record from Crystal River site documents considerable variation in the composition of local plant communities over time. The fluctuations align relatively well temporally with broader-scale environmental changes that are proposed for the Gulf Coast of Florida (or indeed, for the earth system as a whole). The assemblages also suggest that human activity influenced local vegetation communities; the nature and extent of this influence provide an interesting line of evidence for assessing the intensity of activity and/or occupation at the site through time. In this chapter I integrate external and anthropogenic palynological signatures to construct a landscape history of Crystal River site and the larger Crystal River/Salt River drainage system between ca. A.D. 1 and 1500.

Wulfert Sea-level Rise and the Changing Role of Crystal River Site

Several Gulf Coast researchers propose that the Wulfert High transgressive sea-level stand occurred between approximately 300 B.C. and A.D. 550 on the southwest Gulf Coast of Florida (Stapor et al. 1991; Tanner 1991; 1992; Walker et al. 1995). In the Big Bend/Springs Coast region, Goodbred and colleagues (1998), along with Hine and colleagues (1988), also identified a transgressive sea-level event beginning around the turn of the millennium. They make a convincing case that this sea-level pulse transpired relatively quickly in the Big Bend region---during the first century or two A.D.---driving tidal water about two kilometers upstream.
and transforming freshwater marsh systems and low lying swamp/hammock areas into expanses of brackish marsh (also see Hutton 1986 and Wright et al. 2005).

The pedological and micro-botanical data from Core 11 at Crystal River substantiate the nature and timing of this environmental shift along the Springs Coast. The comparison of Zones 4 (72-108 cmbs) and 5 (158-160 cmbs) of Core 11 suggests that a major ecological transition occurred previous to the deposition of Phase 1 midden at the Crystal River site. This transition was characterized by extensive sand deposition (likely successive storm surge deposits) and the replacement of freshwater marsh taxa by tidally-influenced brackish marsh plants and salt-tolerant tree species.

Concurrent with or immediately following this transgressive event, during Phase 1, local forager communities constructed Mound J and deposited great volumes of shell and other midden materials to form an abbreviated comma-shaped ridge along the river bank (Figure 2.3a) (Pluckhahn et al. 2015). These sociocultural developments represent the transformation of Crystal River site from a presumably ‘vacant’ mortuary/ceremonial center to a habitation site and civic node on the landscape. Farther north, near the mouth of the Suwannee River, coastal forager communities also resettled elevated landforms during this period and began constructing large-scale shellworks (McFadden 2015; Sassaman et al. 2014; Wallis et al. 2015).

It is difficult to say at this point whether, how, or to what extent this environmental shift in the Crystal River/Salt River drainage motivated or inspired forager communities to expand mound construction activities and initiate occupation at Crystal River Site. However, it is extremely unlikely that these contemporaneous cultural and environmental landscape transformations were unconnected. For instance, if we assume that fisher-hunter-gatherer communities inhabiting the Crystal and Salt River drainage systems selected habitation and
civic/ceremonial sites based (even partially) upon the physical location of major ecotones---specifically those enabling: the proliferation of oyster (*Crassostrea virginica*), the co-occurrence of freshwater and brackish wetlands, and relatively high tree abundance---then it is quite likely that the development of the Crystal River site as a village and civic center was intricately tied to the upstream relocation of the oligohaline ecotone in response to marine transgression during the last century B.C./first century A.D.

Surveys, coring, and limited excavation at sites constructed at closer proximity to the open gulf in the Crystal River/Salt River drainage, coupled with radiocarbon dating programs and geoarchaeological/paleoecological analyses, would push CREVAP toward a more thorough understanding of Early Woodland-period socioecological events and processes in the Crystal River/Salt River system. The resulting data would be well positioned to investigate the conservation and transformation of sociocultural and socioecological traditions during (and following) a period of relatively dramatic, externally driven environmental change.

*The Wulfert High/Roman Warm Period and the Florescence of Crystal River Site*

Zone 3 (Strata 5 and 6) of Core 11 dates to the late RWP/Wulfert High Stand, aligning with Phase 2 at Crystal River site. The pollen data provide a clear ecological signature supporting the increased precipitation frequency, wetland development, and warmth attributed to this climatic episode (see Watts 1980 for palynological evidence from central Florida). For example, in this climatic context the reduction in cedar pollen at Crystal River suggests, perhaps, that previously haline hammock niches opened up to the less salt-tolerant tree species that appear in Zone 3. Both arboreal and obligate wetland forb assemblages suggest that freshwater wetlands developed in low-lying areas set back some distance from the river (perhaps as they are today at Crystal River Site, in swampy basins some 150-200 m from the river bank). At the same time,
brackish conditions seem to have dominated in the marshes immediately bordering the river, attesting to the slowed but continuing coastal transgression in the Big Bend region that transpired following the A.D. 1-200 transgressive pulse (Goodbred et al. 1998; Hine et al. 1988; Wright et al. 2005). Notably, there is no microbotanical or pedological evidence from Crystal River during the RWP/Wulfert High to suggest a sea-level stand reaching any elevation above modern MSL, as is reported for the Southwest Florida Gulf Coast between A.D. 200 and 500 (Walker 2013; Walker et al. 1995).

There is, however, palynological evidence for the intensification of midden-building activities and mound construction at the Crystal River site during Phase 2. Disturbance marker species, especially those fond of warm and wet conditions, appear in the non-arboreal (Smilax spp., Amaranthaceae-Chenopodium, Solanum americanum, Brassicaceae, Commelina spp.) and arboreal (Salix c.) assemblages during this phase of occupation. As relatively short plants with limited pollen dispersal strategies, the non-arboreal disturbance taxa listed above likely grew atop the midden itself, suggesting that this feature was well above tidal reach and routinely kept in an early successional state (i.e. cleared of woody vegetation) as one would expect at a site with perennial or near-perennial occupation. The proliferation of coastal plain willow also supports the operation of a precipitation-heavy climatic regime, and suggests that wetland areas in the vicinity of the site experienced substantial disturbance (i.e. vegetation removal/harvesting, soil turning, clearing, burning, etc.). The increased abundance of Typha spp. through the early and middle portions of Phase 2 may also indicate intensive site use. Typha spp. outcompetes other emergent marsh taxa (particularly Cladium m. and other sedges) when nutrient levels become elevated (Newman et al. 1996). With this in mind, the proliferation of Typha spp. and the unexpectedly low abundance of Cladium m. during the RWP/Wulfert High may have resulted
from nutrient loading caused by intensified site use. Indeed, the presence of transgressed midden and runoff from Mound A may continue to impact the species composition of the marsh that borders the southwestern section of the site – encouraging the proliferation of *Typha spp.* at the expense of the typically dominant *Cladium m.* marsh (Figure 6.1).

![Figure 6.1. Modern Distribution of Marsh Vegetation Southwest of Crystal River Site (Photo Taken Looking West from the Summit of Mound A, Summer 2016)](image)

The pollen data generally support the interpretation of Pluckhahn and colleagues (2015) and Thompson and colleagues (2015) who propose that Phase 2 forager communities intensified mound construction activities (completing Mounds H, K, and the base of Mound A) and
inhabited the site year-round—depositing thick and dense midden strata containing shells that have yielded isotopic values indicative of perennial seasonality. The fairly optimal climatic conditions and generally stable (slowly transgressive) sea level identified in Zone 3 midden deposits align temporally with the florescence of site activity at Crystal River during Phase 2. The archaeoenvironmental data from Crystal River and Robert’s Island, taken together, suggest that climatic and sea-level conditions played a complex role in the lives of the forager peoples occupying and utilizing Crystal River Site.

Duke (2016) notes that following the end of Phase 1 people at Crystal River began more intensively harvesting shellfish and reduced their consumption of predatory fish, which he interprets as an intentional subsistence strategy focused on exploiting low trophic level faunal resources that replace their populations quickly (principally oyster and mullet in this case). Given the paleoecological and geological data suggesting sea-level stability, increased freshwater input, and the localized position of a favorable oligohaline ecotone during the RWP, local oyster beds would likely have experienced ideal conditions for high recruitment and rapid population replacement, especially if aided by maricultural techniques (see Jenkins 2016). Oysters were clearly an immensely important resource, not only for daily subsistence needs, but also for mound construction. In turn, the construction of shell mound monuments at Crystal River (and later at Robert’s Island) may well have been directly associated with (i.e. facilitated by) large-scale and politically impactful communal consumption (i.e. ‘feasting’) events (see Sampson [2015] for a concise review of southeastern ‘feasting’ and a case study from Robert’s Island). Taking a socioecological approach, it is clear how broad-scale environmental flux may be tied to sociocultural and sociopolitical developments at Crystal River site; however, the relationship is
neither simple nor determinative, but instead involves localized ecological succession patterns and decision making on multiple scales by human agents.

The Buck Key Low/Vandal Minimum: Crystal River Wanes, Robert’s Island Rises

The Buck Key Low sea-level stand and the associated Vandal Minimum climatic episode are modeled as beginning at approximately A.D. 600, and lasting until the onset of the Medieval Warm Period during the ninth century A.D. (Balsillie and Donoghue 2004; Walker et al. 1995). Notably, there is no pedological or other geomorphological evidence for a true sea-level regression in this time frame on the Big Bend coast, as is reported for Charlotte Harbor/Pine Island Sound in South Florida (Goodbred et al. 1998; Hine et al. 1988; Stapor et al. 1991; Walker et al. 1995; Wright et al. 2005).

Zone 2 (Strata 3 and 4) of Core 11 aligns stratigraphically with the terminal portion of Phase 2 (modeled to cal A.D. 221-554 at 2σ) and the nascent portion of Phase 3 (modeled to cal A.D. 478-809 at 2σ) at Crystal River. The pollen assemblage here is distinctly marked by a reduction in taxonomic diversity and the persistence of generalist plants that tolerate wide swings in temperature and precipitation frequency. Dating to just before the projected start of the VM in Southwest Florida at ca. A.D. 600 (see Walker 2000), this ecological shift aligns with major drought events in the circum-Caribbean region around ca. A.D. 585 (Curtis et al. 2001) and likely reflects the response of vegetation at Crystal River to the fallout of the A.D. 536 Dust Event—-proposed as the primary driver of the VM climatic conditions (Gunn 2000; Stothers 1984). An early response by vegetation communities to climatic disturbance makes sense (particularly the response to temperature change), as does a temporal lag in the response by marine and estuarine systems (i.e. the proxies utilized at Southwest Florida sites are largely estuarine or marine faunal remains).
A soil carbon sample from the basal stratum (Stratum 2) of Core 48 yielded a date of cal A.D. 620-680 (2σ). This falls within the Buck Key Low/Vandal Minimum period, but perhaps also within an approximately half-century episode on the Southwest Florida coast (ca. A.D. 650-700) marked by high precipitation frequency and warmth (Wang et al. 2011; 2013). The pollen assemblage from this stratum suggests the local proliferation of oligohaline river-bank marshes with salt-tolerant tree species dominating the hammock-marsh interface and the presence of freshwater wetlands set back some distance from the river. The abundance of Juniperus s., Cyperus spp., and Sagittaria spp. and the presence of other taxa that rely upon frequent rainfall suggest this pollen assemblage may represent a brief period of relatively optimal climatic conditions – most likely the warm and wet episode identified by Wang and colleagues (2011, 2013) in Southwest Florida.

The palynological data dating generally to the VM suggest that several generations of villagers in the Crystal River/Salt River drainage experienced highly variable climatic conditions marked predominantly by cool temperatures and relatively infrequent rainfall, but with punctuated episodes of warmth and frequent precipitation (i.e. ca. A.D. 650-700). This climatic pattern may have been accompanied by a general drop or high variability in sea level/tidal influence and a corresponding decline or movement of the highly productive ecotone characterizing the Crystal River site area during the preceding RWP/Wulfert High.

Pluckhahn and colleagues (2015) present Phase 3 (modeled to cal A.D. 479-809 at 2σ) at Crystal River and Roberts Island as a period of sociocultural transformation, where habitation and mound construction at Crystal River waned and communities intensified midden deposition and mound construction activities downstream at Roberts Island. In the Suwannee River mouth region, Sassaman and colleagues (2014) have documented the occupation of low-elevation,
seaward hammock islands around this time, extending until roughly A.D. 850 (also see Borremans 1991). A sea-level regression, or increased sea-level instability, would offer a seemingly intuitive socionatural explanation for the dispersal and downstream reorganization of forager communities in the Crystal River/Salt River system (and in the Big Bend region more generally) during the VM, resolution issues created during the initial sampling of the cores from Crystal River (not to mention the expense of further radiocarbon dating) dissuade me from directly evaluating Buck Key Low sea-level/tidal influence with my current palynological data.

As mentioned above, recently published zooarchaeological evidence from Crystal River and Roberts Island reveals that shellfish remains, particularly oyster, become increasingly abundant in the faunal assemblage during and after Phase 2 (Duke 2016). This trend corresponds with significant declines in mean trophic level, biodiversity, and equitability – marking a transition in the estuarine subsistence strategy. If, indeed, oyster and other shellfish taxa had become the foci of a highly structured, intensified subsistence strategy by the terminal years of Phase 2, then an environmental shift compromising localized oyster beds and/or encouraging the proliferation of bioherms closer to the Gulf may well have played a role in the settlement shift that transpired during Phase 3. The contemporaneous occupation of Crystal River and Roberts Island through this multi-century cultural phase precludes the notion of a rapid and deterministic sociocultural response to environmental change. Instead, the settlement shift unfolded over generations as ecological transformations interacted with subsistence, economic, political, and perhaps metaphysical social structures. It remains unclear whether the settlement shift transpired via sociopolitical fissioning, corporate decision making, trickling migration of households, or some other processes, but the environmental changes occurring throughout these centuries surely played a role. To better evaluate this dynamic period of socioecological history in the Crystal
River/Salt River system, further research should focus on: palynological analysis of samples from early deposits at Roberts Island, and high-resolution sampling of cores taken in the marsh-covered midden area southwest of Mound A (cores in the southwest marsh area at Crystal River site should be taken to a minimum of 2 m depth).

*The La Costa High/Medieval Warm Period at an ‘Abandoned’ Crystal River Site*

Three stratigraphic loci from Crystal River site contain pollen records dating approximately to the Medieval Warm Period/La Costa High Stand (ca. A.D. 850-1450); and each record supports the local manifestation of these episodes in the Crystal River/Salt River system. The upper stratum of Core 48 (0-46 cmbs) has no carbon dates and (as sampled) represents an inherently low-resolution pollen record. However, the stratum post-dates cal A.D. 620-680 and is clearly a transgressional brackish marsh peat deposit most likely associated with increased tidal influence and an elevated river stage (as expected following the inception of the MWP/La Costa High). The pollen assemblage also suggests an expansion of brackish marshes and haline hammock niches. Further, weedy taxa that favor warmth and frequent rainfall are prevalent in this stratum, supporting the local manifestation of the expected MWP climatic regime. Zone 1 (Strata 1 and 2) of Core 11 aligns with the terminal portion of Phase 3 (modeled to cal A.D. 479-809 at 2σ) and likely also represents some subsequent top soil development. The pollen assemblage in this zone, like Stratum 1 of Core 48, suggests the expansion of brackish marshes (particularly Cladium m. and Cyperus spp.) and haline hammock niches (Juniperus s.). As in Stratum 1 of Core 48, warmth and precipitation loving weedy taxa are abundant in this zone, suggesting warm and wet conditions. Zone 3 (Strata 5 and 6) of Core 55 dates to cal A.D. 880-990 (2σ) and aligns approximately with the first century and a half of the projected MWP/La Costa High on the Gulf Coast. This depositional locale, set back about 200 m from the modern
river bank, recorded the local presence of both generalist and freshwater marsh species. This suggests that while oligohaline marsh species dominated along the river course, expanding into low-lying hammock areas and midden (e.g. atop Stratum 2 of Core 48). The freshwater wetlands in areas set back from the river (near the locations of Cores 55 and 56) remained relatively protected from tidal influence.

The palynological and pedological data from these samples provide evidence for local sea-level transgression in the Crystal River/Salt River system during the MWP/La Costa High. This suggests increased tidal influence throughout the drainage and the expansion of more haline wetland vegetation communities; however it appears quite unlikely that this marine influence was any greater than experienced at present, as freshwater wetlands proliferated in areas that today sit less than a meter above the elevation of the river’s tidal range. If La Costa High sea level rose in the Crystal River system to the elevation proposed for other regions of the Gulf Coast (approximately 1–1.2 m above present), then these wetlands would have been inundated by brackish river water with each tidal cycle and would not have supported the insect-pollenated (i.e. pollen not dispersed on the wind) freshwater-dependent species recorded there in the sedimentary record.

The term “abandonment” in its full sense is likely an inappropriate term for Crystal River during Phase 4 (ca. A.D. 787–1068 at 2σ), as the mound center surely remained a part of the cultural landscape in the region for generations following the cessation of occupation at the site (see Watkins 2006). However, the general absence of anthropogenic deposits dating to this period and the apparent migration of local forager communities to the Roberts Island mound complex suggest that the Crystal River site was no longer utilized for ceremonial functions or habitation (Pluckhahn et al. 2015). With the return of increased tidal influence and stable climate
during the Medieval Warm Period/La Costa High, one might expect that optimal ecological conditions would motivate local forager communities in the Crystal River/Salt River system to re-occupy Crystal River site. Instead, these communities continued to utilize Robert’s Island until its decline in the eleventh century A.D. and never returned to occupy Crystal River. Why people did not return is an open question with a wide array of hypothetical explanations, both testable and non-testable. However, it’s clear that in this case---in keeping with the history of the forager peoples who utilized and occupied Crystal River in subsequent centuries---the nature of their response was not reactionary or determined by externally-driven environmental change.

_Evidence for the Little Ice Age at Crystal River Site_

Zone 2 (Strata 3 and 4) of Core 55 developed between cal A.D. 880-980 (Core 55, Stratum 6) and cal A.D. 1450-1640 (Core 55, Stratum 2), a time period aligning with the onset of the Little Ice Age climatic anomaly. The pollen data from Core 55 suggest that the wetland area to the east of the plaza was affected substantially by this climatic oscillation, with more specialized wetland obligates (i.e. _Saururus c._, _Rhynchospora spp._, _Pontederia c._) declining or disappearing from the assemblage and generalist (disturbance and cold-tolerant) species (i.e. _Sagittaria spp._, _Cyperus spp._, and _Typha spp._) expanding. Further, the pollen data in Zone 1 (Strata 1 and 2) suggest that warmth and high precipitation frequency returned at ca. cal A.D. 1450-1640, as wetland tree taxa and shade-loving emergent wetland forbs (i.e. _Saururus c._) and ferns became abundant. This strong arboreal signature in the uppermost zone of Core 55 may serve as an example of forest recovery following the cessation of anthropogenic impact at the site, as documented in circum-Caribbean and Maya regions (Leyden 1987; Vaughan et al. 1985). In this case, the regeneration of trees may have been delayed by adverse climatic conditions during the onset of the Little Ice Age; however, it is also quite possible that the delay was
facilitated by ecological feedback from the preceding ~1500 years of heavy anthropogenic site disturbance.

**Pollen as a Proxy for Plant Use: Food, Medicine, Fiber, and Timber**

Fossil pollen grains collected from archaeological deposits are generally best thought of as ecofacts – particularly in cases where the pollen emanated from wild plant taxa. As such, to this point I have treated the pollen assemblages from the Crystal River site predominately as ecological and socioecological data sets containing signatures for changes that occurred on the local landscape. However, pollen assemblages, much like phytoliths and macrobotanical remains, can also yield important information about the use of particular plants by ancient peoples (e.g. McLauchlan 2003). When thought of in this way, pollen grains serve as proxies for perishable botanical artifacts. Indeed, archaeological palynology may serve as a valuable supplement to the analysis of macrobotanical remains at Crystal River and Roberts Island, which has yet to be undertaken. Pollen analysis offers a particularly useful method for investigating the past use of non-woody taxa that do not produce durable (or useful) seeds, as these plants seldom leave any macrobotanical trace in archaeological deposits. Such plants (e.g. herbaceous marsh and swamp taxa) abound on the northern Gulf Coast, and many are well documented ethnohistorically as dietary, medicinal, or technological resources among various North American Indian groups (Table 6.1).

**Anemophilious Taxa**

In this study, samples from midden strata in Core 11 were found to contain substantial quantities of pollen from various edible, technologically-useful, and ethnohistorically-documented plant taxa. Indeed, most of the species identified in the pollen assemblages from the midden samples have some ethnohistorically and/or archaeologically documented use. Among
these taxa, many display anemophilous (wind-dependent) pollination strategies and thus cannot be rigorously used to suggest their use in daily or ceremonial life. I do, however, include these plant taxa in Table 6.1, as their pollination strategy does not by any means rule them out as important resources for Crystal River’s ancient inhabitants. Three anemophilous taxa that are well-represented in the midden deposits—*Juniperus silicicola*, *Boehmeria cylindrica*, and *Typha spp.*—deserve greater consideration as botanical resources and are discussed below.

*Juniperus silicicola* (Cupressaceae) or Southern Red Cedar is the smaller, southern variety of the Eastern Red Cedar (*Juniperus virginiana*), though some southeastern botanists consider the two species to be indistinguishable (Adams 1986; Godfrey 1988; Nelson 2011). They are broadly distributed throughout the northern peninsula of Florida, and occur with lesser frequency in the southernmost portion of the peninsula (Nelson 2011:47). In coastal areas, Southern Red Cedar is associated with limestone outcroppings, shell midden, and land areas bordering or isolated by tidal marshes (Kurtz and Wagner 1954). In the nineteenth century, intensive logging operations nearly eliminated the Southern Red Cedar from the northern Gulf Coast of Florida; the strong, rot-resistant wood was (and continues to be) highly prized for tools, carpentry, and fence posts (Gilman and Watson 2014; USDA Forest Service 1969; 1974). During the peak of extraction in the 1880s one account claims that 28,000 cubic meters of trimmed cedar wood were shipped out of the region to pencil factories of New York and the European continent in a single year (Monk 1987; Simmons et al. 1989; Williams et al. 2007). It seems that before this large scale logging effort, centered in Cedar Key and Gulf Hammock, southern red cedars likely formed extensive maritime forests in the Big Bend and Springs Coast regions.
Table 6.1. Ethnobotanically Documented Taxa Present in Core 11 Midden Strata

<table>
<thead>
<tr>
<th>Plant Taxa</th>
<th>Pollination Strategy</th>
<th>Core 11 Presence</th>
<th>Food</th>
<th>Medicine</th>
<th>Ceremony</th>
<th>Fiber</th>
<th>Construction</th>
<th>Sources</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Boehmeria cylindrica</em></td>
<td>A</td>
<td>All Zones</td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td>Jakes and Sibley (1994); Judd et al. (2016:392); Whitford (1941)</td>
</tr>
<tr>
<td><em>Brassica spp.</em></td>
<td>E</td>
<td>Zones 1 and 3</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td>Hamel and Chiltoskey (1975); Speck et al. (1942)</td>
</tr>
<tr>
<td><em>Chenopodium spp.</em></td>
<td>A</td>
<td>Zones 1, 3, and 4</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td>Sturtevant (1955:241, 276, 233, 241)</td>
</tr>
<tr>
<td><em>Commelina spp.</em></td>
<td>E</td>
<td>Zones 1 and 3</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td>Sturtevant (1995:303)</td>
</tr>
<tr>
<td><em>Cladium Mariscus</em></td>
<td>A</td>
<td>Zones 1 and 4</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td>Allen et al. (2002)</td>
</tr>
<tr>
<td><em>Cyperus spp.</em></td>
<td>A</td>
<td>All Zones</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
<td>Harvard (1895:114-115); Vestal (1952:38)</td>
</tr>
<tr>
<td><em>Eleocharis spp.</em></td>
<td>A</td>
<td>Zones 1, 2, 3, and 5</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Hutton (2010); Sturtevant (1955:162, 203, 210, 213, 274)</td>
</tr>
<tr>
<td><em>Juniperus silicicola</em></td>
<td>A</td>
<td>All Zones</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>Harvard (1895:118); Hutton (2010); Jakes and Sibley (1994); Laudonniere (2001); Sturtevant (1955)</td>
</tr>
<tr>
<td><em>Magnolia virginiana</em></td>
<td>E</td>
<td>Zones 1, 3, and 5</td>
<td>X</td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td>Hutton (2010); Laudonniere (2001); Speck (1941); Speck et al. (1942)</td>
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<tr>
<td><em>Morus rubra</em></td>
<td>A</td>
<td>Zone 1</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td>Jakes and Sibley (1994)</td>
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<tr>
<td><em>Pontederia cordata</em></td>
<td>E</td>
<td>Zone 3</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td>Allen et al. (2002); Chandler et al. (1979); Mechling (1959); Speck (1917)</td>
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</tbody>
</table>
Table 6.1. continued…

<table>
<thead>
<tr>
<th>Plant Taxa</th>
<th>Pollination Strategy</th>
<th>Core 11 Presence</th>
<th>Food</th>
<th>Medicine</th>
<th>Ceremony</th>
<th>Fiber</th>
<th>Construction</th>
<th>Sources</th>
</tr>
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<tbody>
<tr>
<td>Sabal palmetto</td>
<td>E</td>
<td>Zones 1, 2, 3,</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>Allen et al. (2002); Cabeza De Vaca (2003 [1542]); Gentleman From Elvas (1995); Hutton (2010); Laudonnier (2001); MacCauley (1887:517); Schneider (2006); Sturtevant (1955); Whitford (1941)</td>
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<td></td>
<td>Hamel and Chiltoskey (1975); Harvard (1895:105-106); Sturtevant (1955); Rogers (1980)</td>
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<tr>
<td>Sagittaria spp.</td>
<td>E</td>
<td>All Zones</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td>Allen et al. (2002); Hutton (2010); Jakes and Sibley (1994); Speck (1941): Sturtevant (1955); Whitford (1941)</td>
</tr>
<tr>
<td>Salix caroliniana</td>
<td>E</td>
<td>Zone 3</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
<td>Austin 2003; Bushnell (1909); Hamel and Chiltoskey (1975); Hudson (1979); Hutton (2010); Morgan and Perry (2010); Sturtevant (1955)</td>
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<td>Saururus cernuus</td>
<td>E</td>
<td>Zones 1, 2, 3,</td>
<td>X</td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td>Allen et al. (2002)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>and 5</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Smilax spp.</td>
<td>E</td>
<td>Zone 3</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td>Allen et al. (20002)</td>
</tr>
<tr>
<td>Thelypteris Kunthii</td>
<td>N/A</td>
<td>Zones 1 and 3</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td>Harvard (1895:115); Sturtevant (1955:267)</td>
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<tr>
<td>Typha spp.</td>
<td>A</td>
<td>Zones 2, 3, 4,</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td>Allen et al. (2002); Core (1967); Jakes and Sibley (194); Speck (1941:60)</td>
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</tbody>
</table>
Southern red cedar, however, has a much deeper cultural history in the American Southeast. Harvard (1895:118) lists various *Juniperus spp.* among his *Food Plants of the North American Indians*, reporting that various historic and protohistoric eastern North American Indian groups harvested juniper cones (“berries”) for bread making. Among the Seminole, Sturtevant (1955) reports the use of *Juniperus virginiana/silicicola* within internal medicines for various illnesses and as a component of ceremonial medicines. In experimental-archaeological work, Jakes and Sibley (1994) identified Eastern/Southern Red Cedar as an ideal source of coarse fiber for various applications in the pre-contact Southeast. Archaeologically, Red Cedar has been recently documented as fuel wood and charcoal (hearth) pottery temper at sites along the St. Johns River Valley (Wallis et al. 2011). Further, the same qualities that made Red Cedar such an ideal construction material in the late historic period would have applied in the protohistoric and ancient past. There is little archaeological evidence from the Gulf Coast for the use of cedar in construction. However, accounts by Cabeza De Vaca (2003[1542]) and the Gentleman of Elvas (1995[1542]) on the central Gulf Coast of Florida describe large houses made from timber (and not palm logs, of which they were well aware). Southern red cedar, while not mentioned specifically, would have posed a functionally ideal construction material for these structures.

Simon (2002) offers an interesting example of the ancient use of Eastern Red Cedar from an archaeobotanical study of burned timbers from 27 Mississippian structures excavated in the American Bottom of Southwest Illinois. Among the structures analyzed, one structure---a temple at the Sponemann Site---was constructed of Red Cedar; elsewhere in the study area, Red Cedar charcoal remains were notably restricted to loci identified as “ceremonial nodes” (Simon 2002:299). In the account from Laudonniere’s 1562 first voyage on the St. Johns River, the
French expedition party is introduced to several different American Indian leaders (‘kings’); and at several of these meetings they note the ‘king’ being seated upon a construction of Cedar and Magnolia wood. Red Cedar, it seems, also served as an important symbolic resource during the contact period in modern-day north Florida (Laudonniere 2001[1562]). The ritual and/or economic importance of Red Cedar on the Northern Gulf Coast during pre-contact and protohistoric eras has yet to be thoroughly investigated, and in the absence of macrobotanical analysis at Crystal River I cannot confidently suggest the use of Red Cedar as a construction, food, medicine, or fiber resource, and certainly cannot speculate as to its ritual significance. However, this study confirms the local presence of these trees throughout the site’s occupation, and it is fair to speculate that the forager peoples of Crystal River likely utilized them in a variety of ways.

*Boehmeria cylindrica* (Urticaceae) or ‘Bog Hemp’ is a broadly distributed herb/shrub that colonizes swamps, marshes, bogs, wet meadows, and ditches (Boufford 1992; Judd et al. 2016:392-393). *Boehmeria c.* and other members of the Nettle family are well known sources of strong, fine-diameter textile fiber; indeed *Boehmeria nivea* or “Ramie” is today an important source of textile and cord-making fiber on an industrial scale (Judd et al. 2016). Jakes and Sibley (1994) experimentally identify Bog Hemp as an exceptionally productive source of fine textile fiber. Indeed, Whitford’s (1941) examination of various ethnohistoric documents and museum artifacts showed convincingly that Nettle Family herbs were selected as a prominent source of cloth and cord fiber among historic and pre-contact Southeastern North American Indian groups (see Willoughby 1938:274 for an interesting archaeological example). The anemophily of *Boehmeria c.* makes it likely that pollen from these plants would appear limitedly in the midden assemblage; however, the exceptional abundance of pollen from this taxa, along with this plant’s
preference for low-lying wetland areas (and not elevated shell ridges), suggests that the *Boehmeria c.* pollen counted in midden strata for this study may represent the processing of these plants for cloth or cord fiber by ancient people at the Crystal River site.

*Typha spp.* (Thypaceae) or Cattail is a ubiquitous and wide ranging emergent wetland plant, colonizing: lake margins, ponds, streams, marshes, wet meadows, ditches, and various low-lying disturbed areas (Judd et al. 2016:305-306). It responds prolifically to excess nutrient loads (see Newman et al. 1996), and grows at exceptional rates through the spring and summer through the rhizomatic propagation of new shoots. It is relatively widely known that most elements of the Cattail plant are edible, including: the pollen, lateral rhizomes, shoot-cores, and immature staminate inflorescences (Core 1967; Judd et al. 2016:305; Thayer 2006:87-100). Indeed, Allen and colleagues (2002) identify *Typha spp.* as an indigenous Florida food resource, and Speck (1941:60) reports its use in medicines for pulmonary conditions, burns, diarrhea among the Houma. The tough, elongated leaves of Cattail plants also lend themselves to various technological applications. Jakes and Sibley’s (1994) experimentation showed that *Typha spp.* would have been an ideal source of coarse fiber for basketry and mats. Indeed, Core (1967) and Allen and colleagues (2002) describe the use of Cattails for woven mats, thatching, and basketry.

*Typha spp.* pollen is widely dispersed on the wind, and the plants stand a meter to a meter and a half above their growing substrate (Judd et al. 2016:305-306). This wide pollen dispersal and the propensity of these plants to (quickly) colonize disturbed areas with high nutrient loading makes the presence of pollen grains in Crystal River midden deposits relatively unremarkable from a subsistence and technology perspective. However, the exceptional utility of these plants as dietary, medicinal, and coarse fiber resources, along with documented use among historic
period American Indians, makes it more than likely that people at Crystal River made use of cattails for various purposes.

*Entomophilious Taxa*

The midden assemblages also contain many entomophilious (insect-pollenated) plant species with pollen dispersal patterns generally limited to areas directly below vegetation stands and/or, of course, loci where plant material has been processed, utilized, and/or discarded. Three particular entomophilious taxa present in the midden assemblages—*Sagittaria* spp., *Saururus cernuus*, and *Pontederia cordata*—are freshwater wetland herbs that grow at low-lying elevations with standing or flowing water. The robust presence of their pollen in the elevated midden ridge at Crystal River is not well explained by natural processes, and instead, likely involved the processing, use, or discard of these plants atop the midden. Another consideration is that freshwater wetland soils (containing the emergent plant pollen) may have been processed for some use atop the midden feature. This hypothesis is also quite interesting, and there is no reason to treat these hypothetical depositional processes as mutually exclusive; indeed, it would be difficult to process these wetland plants without depositing soils, and vice versa.

*Sagittaria* spp. (Alismataceae) or Wapato is a widely distributed emergent wetland herb colonizing freshwater marshes, swamps, lake margins, stream banks, and ditches (Judd et al. 2016:266-268). Wapato plants (like *Typha* spp.) are tolerant of high concentrations of nutrients and heavy metals, and are frequently utilized by land managers for improving water quality in ecological engineering projects (e.g. Marburger 1993). Mature Wapato plants prefer soft, deep mud and ample sunlight, but can thrive in widely ranging water depths (10-46 cm) (Thayer 2006:101-116). Large stands typically develop in “sloughs and backwaters of rivers and streams where water levels fluctuate rapidly with rainfall” (Thayer 2006:107-108).
Wapato is a well-documented ethnobotanical resource among North American Indian groups; and various eastern and pacific slope aboriginal groups harvested Wapato tubers as important food resources (Garibaldi 2003; Harvard 1895:105-106; Rogers 1980:26; Suttles 1990). These tubers were “formerly among the four most important underground starch sources of the coastal Salish” and were also heavily utilized by the Katzie (Garibaldi and Turner 2004). Garibaldi and Turner (2004) make a convincing case that Wapato constituted a Cultural Keystone Species---taxa crucial to the operation of both local ecosystems and sociocultural and economic systems---among Pacific slope American Indian/First Nations groups. They describe how land modification (i.e. filling/draining of wetlands) during the advancement of European agriculture decimated regional populations of *Sagittaria spp.* and brought about a major transformation of indigenous subsistence strategies. *Sagittaria spp.* is also well documented as a medicinal resource. The Potawatomi, Lakota, Iroquis, Cheppewa, Cherokee, and Seminole utilized various parts of the Wapato plant for topical medicines for wounds, sores, and boils; further, the Chippewa and Iroquois utilized Wapato for internal medicines---gastrointestinal, antirheumatic, and laxative aids (Densmore 1928:342; Hamel and Chiltoskey 1975:23; Mechling 1959:124; Rogers 1980:26; Smith 1933:37; Sturtevant 1955:298). The abundance of *Sagittaria spp.* pollen in the midden assemblages from Crystal River, when considered along-side the ecology and pollination strategy of this taxa, suggests that the ancient fisher-hunter-gatherers occupying Crystal River site utilized Wapato in some way; and the ethnohistoric use of this plant genus makes it quite plausible that Wapato may have been a subsistence and/or medicinal resource.

* Saururus cernuus *(Saururaceae) or Lizard’s Tail is also an emergent freshwater wetland herb, colonizing the understory of swamps, marshes, stream banks, and lake margins, and can
tolerate a relatively wide temperature range (Boyd and Walley 1972; Hall 1940; Thien et al. 1994). Lizard’s Tail is well documented ethnobotanically—known in Southwest North America by its Spanish name “Yerba Mansa” and in the Southeast by several names in different indigenous languages: “Ishuna ignore” in Choctaw, “Cyihiliswa” in Creek, “Yahkakayikci” in Mikasuki (Austin 2003). Its ethnobotanical uses seem predominantly as medicine and ceremonial medicine. The Cherokee, Choctaw, Ojibwa, Powhatan, and Seminole all utilized Lizard’s Tail in topical poultices for wounds (Austin 2003; Bushnell 1909:23; Hamel and Chiltosky 1975:43; Morgan and Perry 2010; Reagan 1934:231; Sturtevant 1955:161, 204, 272, 286, 307, 409). Austin (2003) and Sturtevant (1955) both note the use of *Saururus c.* in several internal medicines, as a mild tranquilizer, and as a ceremonial emetic in connection with ‘Poskita’ fasting before Green Corn Ceremonies (also see Hutton 2010 and Hudson 1979). The chemistry of *Saururus c.* lends itself to medicinal use—containing antiseptic and antitumor compounds, as well as antioxidant, antiviral, and sedative compounds (Rao 1990; Rao and Reddy 1990). The abundance of *Saururus c.* in Phase 2 midden deposits at Crystal River, given its habit and pollination strategy, suggests that inhabitants likely handled, processed, and/or disposed of these plants atop the midden; and the ethnobotanical history of this plant makes it relatively likely that people utilized Lizard’s Tail as medicine and/or in ceremonial preparations.

*Pontederia cordata* (Pontederiaceae) or Pickerel Weed, like *Sagittaria spp.* and *Saururus c.* is an emergent freshwater wetland herb that colonizes tidal marsh, ponded areas, and stream banks (Judd et al. 2016:298-300). In tidally influenced freshwater wetlands, the seeds of Pickerel Weed germinate most optimally along stream banks in areas with relatively high soil temperatures (Simpson 1983). The North American historical ethnobotany of *Pontederia c.* is not as well developed as the previous taxa discussed here; however, indigenous groups in the
Northeast (Milecite, MicMac, and Montagnais) are known to have utilized Pickerel Weed as a food (corm) and medicinal (contraceptive, panacea) resource (Chandler 1979:59; Mechling 1959:259; Speck 1917:315). The presence of *Pontederia c.* in the midden strata at Crystal River, though slight, may suggest the use Pickerel Weed as a subsistence or medicinal resource; alternatively, the *Pontederia c.* pollen may have been deposited during the processing of other freshwater wetland plants.

*Sponge Spicules*

The additional/alternative hypothesis posed above---that wetland soils were processed atop the midden---is attested to by the abundant presence of sponge spicules in the midden strata. Sponge spicules are substantially more concentrated in Core 11 midden deposits (Zones 2, 3, and 4) that they are in the sampled environments where sponges naturally proliferate, in shallow water wetlands (i.e. Stratum 1 of Core 48 and all zones of Core 55). This suggests that wetland soils were deposited atop the midden with some regularity, enabling the concentration of sponge spicules in an environment where they would not occur naturally. Notably, the most desirable elements of the wetland herbs discussed here (and many listed in Table 6.1) are roots, corms, and tubers, each of which would require extracting the plant from its mud substrate and a substantial effort in washing, scrubbing, etc. During this process, some volume of mud (containing spicules) would be washed to the ground surface at the location of processing. Even if the pre-cooking processing was minimal and cooking water was dumped or spilled in the midden area, this water would contain sponge spicules---transporting them from the original wetland growing medium to the elevated shell-ridge midden deposits. Wetland mud may have also been harvested directly for any number of purposes; for example, Lollis and colleagues (2015) show experimentally that St.
Johns series pottery was quite likely tempered with wetland mud containing the sponge spicules that make the paste of this aboriginal ceramic series so distinctive.

**Absent Plant Taxa**

One advantage of fossilized pollen as a proxy for vegetation communities is that, unlike most paleontological (and indeed, archaeological) remains, the absence anemophilious pollen in a depositional record suggests its relative absence from the local landscape. Fisher-hunter-gatherers on Florida’s Gulf Coast have long been noted for their resistance to the adoption of the old eastern agricultural complex, and later, maize agriculture. Archaeobotanical remains recovered from the Pineland site in southwest Florida, including: squash (*Cucurbita pepo*), pepper (*Capsicum spp.*), and papaya (*Carica papaya*), have begun to complicate this understanding somewhat (Newsom and Scarry 2013:253-304). Newsom and Scarry (2013) also report an interesting concentration of *Chenopodium* spp. seeds that may suggest the use of these ruderal plants for subsistence. At Crystal River site, the moderate abundance of *Amaranthaceae* pollen discourages the notion that *Chenopodium* was a subsistence resource of any consequence. The absence of pollen from squash, pepper, and papaya is not surprising, as these plants are insect-pollinated and are utilized for their fruits (i.e., there is no incentive to dispose of inflorescences). Indeed, *Cucurbita pepo* likely served as a somewhat ubiquitous botanical resource for Florida Indian groups, with its association with Florida archaeological sites extending back to the Pleistocene-Holocene transition (Newsom et al. 1993). Macrobotanical and phytolith analyses of midden matrix and feature strata from Crystal River site stand the best chance of recovering evidence for the use of these plants.

The issue of maize in pre-Columbian peninsular Florida has been somewhat tenuous (e.g. Sears 1982; Thompson et al. 2013), but in general archaeological and bioarchaeological
evidence suggests that maize was not a meaningful (if present) subsistence resource until the
mission period (see Hutchinson 2004; Hutchinson et al. 1998, 2016). The argument for maize
consumption on the Gulf Coast stems in part from the 1542 ethnohistoric account of Alvar
Nunez Cabeza de Vaca, who chronicled the Narvaez expedition. Coming ashore in the Tampa
Bay area in the spring of 1528, de Vaca describes two plots of sown maize.

Additionally, stable isotope analyses on human skeletal elements from several peninsular
Florida sites (including Crystal River site) show that C_4 plants were likely a part of the diet at
select coastal sites (e.g. Bayshore Homes, Bay Pines, Dunwoody), and may have made up a more
substantial portion of the diet at inland sites in the north-central peninsula (e.g. Cross Creek and
Melton Mound I) (Kelly et al. 2006; Tykot et al. 2005). Kelly and colleagues (2006) explicitly
attribute these C_4 dietary contributions to the adoption of maize, arguing simply that it is
doubtful that other C_4 and CAM plants made up enough of the diet at inland sites to produce the
elevated signatures observed. At coastal sites, they argue that C_4 signatures observed in several
individuals are also likely attributable to maize consumption, additionally emphasizing that two
juvenile individuals excavated from Bayshore Homes exhibited instances of dental caries (Snow
1962).

The appearance of maize in north-central Florida during the middle-late Woodland would
not necessarily be shocking, and certainly some limited exchange of maize to the Gulf Coast is
also not improbable. However, given the absence of archaeobotanical evidence for maize
consumption, it seems premature to asset that these C_4 signatures “strongly suggest an early
introduction of maize” (Kelly et al. 2006:259). Many native plant taxa yield C_4 or C_4-like
isotopic values, including prickly pear (*Opuntia* spp.), and various terrestrial grasses. At coastal
sites, an abundance of native C_4 sea-grasses (e.g. *Thalassia* t., *Syringodium* f., *Halodule* w.,
Halophila spp.) and the intensive consumption of fish that feed on these grasses (i.e. Mugil spp.) may in part explain the observed isotopic values. Further, various emergent aquatic plants, such as those in the sedge family (Cyperaceae), have retained a C₄ photosynthetic pathway (Besnard et al. 2009; Mei-Rong et al. 1999), or may express this pathway in response to particular environmental conditions (Ueno 2001). The exceptional abundance and ubiquity of sedges in wetland ecosystems along the Gulf Coast (and in the interior of the peninsula) complicates the assumption that bioarchaeological C₄ plant signatures can be attributed exclusively to maize consumption.

Given the anemophily of Zea mays, the pollen record within midden and wetland deposits at the Crystal River site almost certainly would yield this plant’s distinctive pollen grains if it was growing in any abundance anywhere in the proximity of the site. Indeed, even if maize kernels or other plant elements were brought to the site from far afield this activity would likely have resulted in the deposition of maize pollen. Instead, no maize grains were encountered in any sample from the Crystal River site, suggesting that maize was not a subsistence resource for people at Crystal River and was not likely a considerable part of inter-regional exchange.

Another plant absent from this pollen analysis is yaupon holly (Ilex vomitoria), from which the famous ‘Black Drink’ was principally brewed (Hudson 1979). Despite the entomophily of this genus, I expected to find Ilex pollen in the midden strata samples. Moore (1903; 1907; 1918) recovered a trove of whelk shell dippers/drinking cups from mound contexts at the site, and given the other evidence that the mound complex served as a ceremonial node I expected that yaupon would have been processed in such abundance (or frequently enough) that inflorescences and pollen from this shrub/tree would have been dispersed across various activity areas. However, the absence of an entomophilious plant species like Ilex vomitoria from the
pollen record does not rigorously suggest its local absence, and if the processing and ‘discard’ of yaupon was restricted to particular activity areas not sampled here (i.e. mounds, plazas, etc.) then we should not expect its representation in the midden and wetland pollen assemblages. Further microbotanical research taking a more comprehensive intra-site approach will be well-positioned to address the potential use of yaupon at Crystal River.
CHAPTER SEVEN: KEY FINDINGS AND APPLICATIONS

Key Findings

The palynological record from the Crystal River site addresses both paleoecological and socioecological issues that have been understudied on the northern peninsular Gulf Coast. The late Holocene landscape histories of the Crystal River site and the Crystal River/Salt River system were marked by dynamic coastal transformations involving fluctuating climatic conditions and sea level. Broad scale environmental changes were heavily tempered by geomorphology and biological communities unique to the Big Bend/Springs Coast regions. The sea-level-episode models developed elsewhere on Florida’s Gulf Coast from marine proxies and beach ridge sets only very generally correlate with the timing of environmental changes in the Crystal River/Salt River system; and the eustatic events that drove these changes manifested themselves quite differently on the Springs Coast. The greater-than-present sea-level stands documented in Pine Island Sound are not supported by the paleoecological evidence from Crystal River, and there is no evidence for true sea-level regression at the site. In contrast, the pollen data reported here suggest that local vegetation communities responded, more or less, as expected to broad-scale late Holocene climatic episodes---the RMP, VM, MWP, and LIA.

The transformation of Crystal River site from vacant mortuary center to village and civic center unfolded following a major transgressive event that pushed brackish wetlands, freshwater wetlands, and freshwater-dependent upland hammocks up to two kilometers inland. The data
synthesized here strongly suggest that this external environmental forcing played an important role in the reorganization of the socioecological landscape in the Crystal River system.

In the following two centuries at Crystal River the pollen data provide clear ecological signatures supporting the increased precipitation frequency, wetland development, and warmth attributed to the RWP climatic episode. This period of optimal climate extended through the second phase of occupation at Crystal River (ca. A.D. 221-554), which saw the florescence of mound building and habitation activity. Disturbance marker species proliferated in both wetland and midden areas during this phase, suggesting that these areas were kept mostly clear of woody vegetation; and the dominance of cattails over other marsh taxa suggests that the local marshes were experiencing high levels of nutrient input.

The pollen data aligning temporally with the Buck Key Low/Vandal Minimum suggest that several generations of villagers in the Crystal River/Salt River drainage experienced highly variable climatic conditions marked predominantly by cool temperatures and relatively infrequent rainfall, but with punctuated episodes of warmth and frequent precipitation (i.e., ca. AD 650-700) as identified by Wang and colleagues (2011, 2013) in southwest Florida. This time period was also one of sociocultural transformation, as habitation and mound construction at Crystal River waned and communities intensified activities downstream at the Robert’s Island complex. A local sea-level regression, or even increased sea-level instability, would offer an intuitive socionatural explanation for the dispersal and downstream reorganization of forager communities, but my current data do not strongly suggest that such a regression occurred, and marine geological evidence suggests that sea-level transgression slowed, but never halted or reversed. In either event, the multi-century contemporaneous occupation of both Crystal River and Robert’s Island precludes the notion of a rapid and deterministic sociocultural response to
environmental change. Instead, the settlement shift unfolded over generations as ecological transformations interacted with subsistence-related, economic, political, and perhaps metaphysical social structures.

A paucity of anthropogenic deposits dating to the La Costa High/Medieval Warm Period at Crystal, and the apparent migration of local forager communities to the Roberts Island mound complex suggest that the Crystal River site was no longer heavily used for ceremonial functions or habitation after about A.D. 900. With the return of increased tidal influence and stable climate during the La Costa High/MWP, one might expect that optimal ecological conditions would motivate local forager communities in the Crystal River/Salt River system to re-occupy Crystal River site. Instead, these communities continued to utilize Robert’s Island until its decline in the eleventh century A.D. and never returned to occupy Crystal River. Why people did not return is an open question with a wide array of hypothetical explanations, both testable and non-testable. However, it’s clear that in this case, in keeping with the history of the forager peoples who utilized and occupied Crystal River in subsequent centuries, the nature of their response was not reactionary or determined by externally-driven environmental change, and must have been primarily based in human agency.

The ecologically and biologically unexpected abundance of both Sagittaria spp. and Saururus c. in the midden deposits from Crystal River, along with the extensive ethnohistoric documentation of these taxa as food and medicinal resources in the southeast, enable me to suggest that these emergent wetland plants were harvested, processed, and utilized in some capacity by ancient Crystal River peoples. Further, while it requires a greater level of inference, certain wind-pollinated taxa that are especially abundant in the midden deposits---particularly Boehmeria c, Juniperus s., and Typha spp---also may have been processed and utilized in the
ancient past for a variety of technological, dietary, and medicinal purposes. This ethnobotanical evidence, if combined with yet-to-be-conducted macrobotanical analysis of midden strata and phytolith and/or starch grain analysis of pottery sherds, may comprehensively explain the roles of various botanical resources in ancient diet, technology, and ceremony. At very least, the abundance of these taxa in the pollen assemblage represents a strong rational for incorporating microbotanical analysis into standard archaeobotanical practice at Gulf Coast sites, or indeed anywhere that herbaceous plants without persistent or desirable seeds may have been an important part of ancient lifeways.

This study represents one of the first successful archaeopalynological studies on the peninsular Gulf Coast, demonstrates the utility of microbotanical data for reconstructing environmental and socioecological histories, and underscores the need for localized paleoenvironmental reconstructions in Gulf Coast archaeology.

**Future Archaeological Research**

Archaeologists working along Florida’s peninsular Gulf Coast are actively seeking reliable, localized reconstructions of ancient environments---and environmental change---at various temporal and spatial scales (e.g. Austin et al. 2014; Austin and Mitchem 2014; Marquardt 2014; McFadden 2015; Pluckhahn et al. 2015; Sassaman et al. 2011). As demonstrated here, fossil pollen assemblages provide proxy data for both climatic and sea-level reconstructions, and can be worked with at both fine and coarse temporal-spatial resolutions. Further, unlike many of the most frequently relied upon Late Holocene reconstructions (i.e. Balsillie and Donoghue 2004; Stapor et al. 1991, Tanner 1991; 1992; 1993) palynology offers coastal archaeologists a line of evidence for investigating not only externally-driven
environmental change, but also anthropogenic landscape alteration, and sociohistorical research questions.

Addressing the ‘Big Bend’ Gulf Coast in particular, Sassaman and colleagues (2014:145) define the sociohistorical past as “the realm of experience where perceptions of environmental change and imaginations of alternative futures are crafted, contested, and recrafted.” Pollen analysis opens a window into this “realm” because fossil pollen assemblages deposited in archaeological contexts record histories of human-environmental interaction that can be synthesized with settlement patterning, subsistence, and technological data to investigate the conservation and/or transformation of sociohistorical traditions through time. This study also shows that pollen analysis of midden strata, household features, and other anthropogenic deposits has the potential to speak more directly to paleoethnobotanical research questions at gulf coast sites and elsewhere. In particular, pollen analysis can detect evidence for the use of plant taxa that do not typically produce durable macrobotanical remains, and additionally may serve as a relatively good indicator for the absence of certain anemophilous taxa.

**Future Paleoecological Research**

Palynology as a discipline has a long history in environmental reconstruction and has been integrated relatively well with archaeological research in the Southwestern U.S. (e.g. Gish 1991; Fish et al. 2006; Martin 1963), Central America (e.g. Binford et al. 1987; Leyden 1987), the Circum-Caribbean (e.g. Curtis et al. 2001; Higuera-Gundy et al. 1999; Newsom and Wing 2004), and the Southeastern U.S. (e.g. Delcourt 1987; Delcourt and Delcourt 1987, 1988; Delcourt et al. 1986). Its use in Florida, however, has been mostly limited to natural history research (see Faught and Carter 1998; Saunders 2009 for exceptions), has focused largely on the Pleistocene-Holocene transition and earlier time periods, and has been limited to the center of the
state where lakes with deep-time sedimentary records are located (e.g. Grimm 2006; Hansen et al. 2001; Watts 1969, 1971, 1980; Watts and Hansen 1994). As shown in this study, palynology can also be used to help reconstruct more recent environmental histories during the late Holocene, and can serve as a valuable proxy for reconstructing coastal environmental change.

The archaeopalynological perspective may be applied as an interpretive lens through which to evaluate or reevaluate paleoecological records constructed for academic and/or compliance based research. Many modern ecologists and paleoecologists, some with substantial archaeological training, now recognize that ancient, as well as historic, human land use heavily influenced the trajectory of various ecosystems across the planet (e.g. Balee 1998; Braje and Erlandson 2013; Braje and Rick 2010; Campbell and Butler 2010; Delcourt et al. 1986; Whitmore et al. 1996). Indeed some researchers are looking to the ancient past to identify the early beginnings of anthropogenic changes to the Earth System that are more frequently associated with the Great Acceleration of environmental impact during mid-twentieth century (Foley et al. 2013; Lewis and Maslin 2015; Ruddiman 2005; Steffen et al. 2015). However, this perspective is relatively modern, and is not universally accepted; thus there is ample opportunity for the investigation of socioecological signatures within existing and future stratigraphic palynological records.

Many paleoecological reconstructions completed in the nineteenth and twentieth centuries (and some more recently) were interpreted under a scientific paradigm that did not account for the role of ancient human landscape alteration. There is enormous potential for researchers trained in both archaeology and paleoecology to reinterpret these environmental records from a historical-ecological perspective and create more sociohistorically inclusive (and more scientifically accurate) landscape histories (see Scharf 2010 for an example from the Yazoo...
Basin). Further, some sediment cores taken for compliance-related historical ecological reconstructions of various wetland environments are not fully analyzed below a certain depth because the research design is limited to investigating the transformation of ecological systems during the past few centuries. The sediment below target depths may hold immeasurable value for the reconstruction of ancient environmental conditions, or even for the reconstruction of anthropogenic landscape alteration that occurred centuries or millennia before modern land use/development. Increased collaboration between archaeologists and paleoecologists could result in the mass availability of high-resolution paleolimnological and other sedimentary records for both academic and compliance-related archaeological applications, and in turn, could extend historical studies of ecological change into pre-contact time periods.

**Archaeopalynology and Modern Climate Change in Florida**

Faced with rising seas (Church and White 2006; Vermeer and Rahmstorf 2010), the increasing intensity and frequency of cyclonic storm events (Bender et al. 2010), and unbridled residential and commercial development, the state of Florida is slowly, but steadily, coming to terms with modern climate change. These environmental transformations have the potential to cripple coastal economies that, as of 2010, were home to three quarters of the state’s residents and were responsible for nearly 80 percent of the state’s annual economy (Florida Oceans and Coastal Council 2010).

Responses to modern climate change must rely heavily upon environmental data tracking the transformation of ecosystems over time and the impacts of these changes on the availability of natural resources (e.g. DeSantis et al. 2007; Doyle et al. 2003; Williams et al. 1999). In turn, paleoenvironmental and historical ecological research is essential for setting baselines in order to understand historic, modern, and future environmental changes (e.g. Hine and Belknap 1986;
Hine et al. 1988; Goodbred et al. 1998; Parkinson 1989; Parkinson and Donoghue 2010). As demonstrated here, palynology offers a useful proxy for reconstructing how coastal ecosystems response to past sea-level transgressions and climatic shifts. If, as suggested by my review of Gulf Coast sea-level reconstructions, eustatic sea-level episodes were experienced variably by different regions of the peninsular Gulf Coast in the past, then they are likely to do so in response to modern and future sea-level rise. Accordingly, locally and/or regionally-focused baseline data (i.e. Mid – Late Holocene climate and sea-level reconstructions) should be made available for all coastal (and inland) regions of the state, as land management strategies for responding to sea-level rise and climate change will need to address unique environmental processes in each physiographic region.

The development of archaeopalynological reconstructions may be especially fruitful in this endeavor for a number of reasons. Firstly, archaeological research facilitates access to relatively intact depositional sedimentary records that extend throughout the Holocene epoch; some archaeological deposits will offer already-established chronological control and/or already-analyzed paleoenvironmental records (e.g. stable isotope records, faunal analysis, or pedological data). Additionally, inter-disciplinary research efforts may offer greater applicability/circulation, greater publication potential, and may be more likely to receive funding from a number of sources. Perhaps most importantly, archaeopalynological research designs inherently include human histories within the historical and paleoenvironmental reconstructions; and “In this understanding of the relationship among place, community, and history, archaeology brings a humanistic element that puts environmental data into perspective” (Sassaman et al. 2011:159). This humanistic element includes not only records of human impact on local and regional ecosystems, but also valuable histories of human social response to, and interaction with,
variously scaled environmental changes. When thought of this way, our modern and future responses to climate change and sea-level rise will represent only the most recent chapter in a deep history of socionatural response to the transformation of dynamic interglacial environments on Florida’s Gulf Coast.
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APPENDIX A: POLLEN CONCENTRATION PROCEDURE

Set Up

1. Set up record log to track the procedure for each sample – Designate sample #s
2. Start heating block/bath for 100 °C
3. Allocate 1ml Microbeads (5000 spheres/ml) for each sample.
4. Set up two sets of LABELED 15 ml tubes in a tube rack
   - Set 1 – Samples, Set 2 – Stir Sticks
   **Make sure sample and stir stick tubes are labeled in multiple places

Sample Preparation

Deflocculation

5. Wash sample with DI water, vortex, and centrifuge. Decant into sink.
6. Add 5 ml of 5 percent KOH, vortex. Place into heat block for 20 min. centrifuge.

Decant

7. Wash with DI Water, vortex, centrifuge, and decant into sink.
*Repeat last step until supernatant is clear.

Sieving – remove particles >125 um

8. Suspend sediment in 5 ml of warm 5 percent KOH.
9. Sieve samples through 125 um nylon mesh via DI water pressure INTO CLEAN, LABELED 50ml tubes.
10. Rinse with DI Water, centrifuge, and decant into sink.

Removal of CaCo$_3$ with HCl

11. Add 5 ml of 10 percent HCl. Use ETOH to control effervescence. Vortex after effervescence stops. Place in Heat Block for 5 min. Centrifuge, and decant into sink.

**Heavy Liquid Separation – “Flotation”**

13. Disperse sediment into a saturated solution of ZnCl₂, Stir Well and Centrifuge.

14. Decant Supernatant (organics) into a 140ml beaker with (up to 100 ml) DI Water and add a few drops of HCl (prevents precipitation of Zn(OH)₂

15. Pour into 50 ml tubes, centrifuge, and decant into waste bottle.

16. Make a “wet mount” of the heavy fractions (remaining from #15 ZnCl₂ flotation) to confirm that no pollen cells remain. Repeat if necessary.

**Acetolysis- Remove Cellulose**

17. WORKING UNDER THE HOOD, wash samples with 5ml Glacial Acetic Acid. Centrifuge with bucket covers in place. Decant into Glacial Acetic waste container.

18. WORKING UNDER THE HOOD, and AVOIDING ANY CONTACT WITH WATER, add 4.5 ml acetic anhydride and .5 ml concentrated Sulfuric Acid to each tube. Place in 100C heat block for 3 min. Centrifuge with bucket covers in place. Decant into acetic anhydride waste container.

**Sieving- remove particles < 7 um**

19. Re-suspend sediment in warm KOH. Sieve sample with 7 um nylon mesh. Wash fine particles through mesh with DI water. Vibration will be necessary. Check for lumps…break them up. Repeat if necessary. Rinse sample caught by the screen into a clean 50 ml tube. Centrifuge and decant into sink.

**Dehydration**

20. WORKING UNDER THE HOOD, dehydrate samples by adding 5 ml TBA (tertiary butyl alcohol). Centrifuge and decant into TBA waste container.

21. Re-suspend sediment in a small amount of TBA and transfer to labeled ½ dram vials. Centrifuge with bucket covers in place. Decant into TBA waste container.

22. Suspend Sediment in silicone oil equal in amount to the organic residue in the vial. Stir each vial thoroughly with a tooth pick. Leave ‘uncovered’ overnight at 50 C to allow evaporation of TBA. Cap and store at Room temp.

**Prepare Slides**
APPENDIX B: REFERENCE SAMPLE PROCESSING PROCEDURE

Set Up

1. Set up record log to track the procedure for each sample – Designate sample #s
2. Start heating block/bath for 100 C
3. Set up two sets of LABELED 15 ml tubes in a tube rack
   - Set 1 – Samples, Set 2 – Stir Sticks

**Make sure sample and stir stick tubes are labeled in multiple places

Sample Preparation

Deflocculation

6. Wash sample with DI water, vortex, and centrifuge. Decant into sink.
7. Add 5 ml of 5 percent KOH, vortex. Place into heat block for 20 min. centrifuge. Decant into sink
8. Wash with DI Water, vortex, centrifuge, and decant into sink.

*Repeat last step until supernatant is clear.

Sieving – remove particles >125 um

9. Suspend sediment in 5ml of warm 5 percent KOH.
10. Sieve samples through 125 um nylon mesh via DI water pressure INTO CLEAN, LABELED 50 ml tubes.
11. Rinse with DI Water, centrifuge, and decant into sink.

Removal of CaCO₃ with HCl

12. Add 5 ml of 10 percent HCl. Use ETOH to control effervescence. Vortex after effervescence stops. Place in Heat Block for 5 min. Centrifuge, and decant into sink.
**Acetolysis- Remove Cellulose**

14. WORKING UNDER THE HOOD, wash samples with 5ml Glacial Acetic Acid. Centrifuge with bucket covers in place. Decant into Glacial Acetic waste container.

15. WORKING UNDER THE HOOD, and AVOIDING ANY CONTACT WITH WATER, add 4.5 ml acetic anhydride and .5 ml concentrated Sulfuric Acid to each tube. Place in 100 C heat block for 3 min Centrifuge with bucket covers in place. Decant into acetic anhydride waste container.

**Sieving- remove particles < 7 um**

16. Re-suspend sediment in warm KOH. Sieve sample with 7 um nylon mesh. Wash fine particles through mesh with DI water. Vibration will be necessary. Check for lumps...break them up. Repeat if necessary. Rinse sample caught by the screen into a clean 50 ml tube. Centrifuge and decant into sink.

**Dehydration**

17. WORKING UNDER THE HOOD, dehydrate samples by adding 5 ml TBA (tertiary butyl alcohol). Centrifuge and decant into TBA waste container.

18. Re-suspent sediment in a small amount of TBA and transfer to labeled ½ dram vials. Centrifuge with bucket covers in place. Decant into TBA waste container.

19. Suspend Sediment in silicone oil equal in amount to the organic residue in the vial. Stir each vial thoroughly with a tooth pick. Leave ‘uncovered’ overnight at 50 C to allow evaporation of TBA. Cap and store at Room temp.

**Prepare Slides**
APPENDIX D: EXAMPLE PHOTO RELEASE FORM

PHOTO RELEASE FORM

For M.A. Thesis Publication

Kendal Jackson

I hereby give permission to Kendal Jackson to use my name and photographic likeness in all forms and media for advertising, exposition displays, trade, and any other lawful purposes, most immediately including publication of his M.A. Thesis: The Archaeopalynology of Crystal River Site (8CI1), Citrus County, Florida.

Print Name: ________________

Signature: __________________

Date: ______________