# A First Millennium A.D. Vegetation History from the Crystal River Site (8CI1), Florida

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## ABSTRACT

*While seldom integrated within coastal archaeological research in Southeastern North America, vegetation histories derived from palynological data offer valuable records of ancient landscape transformations driven by climatic flux, sea-level oscillations, and anthropogenic modifications. In this paper, we develop a paleo-historical-ecological reconstruction from preliminary analyses on fossil pollen assemblages preserved within marsh, hammock, and shell-midden soils at the Crystal River site (8CI1), a mound center on Florida's west-central coast occupied throughout the first millennium AD. When contextualized alongside paleoenvironmental records from western Florida and farther afield, our analysis suggests that the nature and timing of late-Holocene climatic changes varied little between different sub-regions of Florida's Gulf Coast, but also that manifestations of eustatic sea-level flux may have been highly localized.*

**Keywords** Florida Gulf Coast, pollen analysis, historical ecology, shell middens

On Florida's peninsular Gulf Coast ancient fisher-hunter-gatherer peoples carried out diverse maritime lifeways that articulated intricately with terrestrial, marine, and estuarine ecosystems. Coastal environments are fundamentally dynamic and continuously reorganize themselves in response to changing climatic conditions, sea-level oscillations, biogeographic shifts, and anthropogenic modifications. As such, localized histories of environmental change are critical in coastal archaeology for providing context from which we may develop and test hypotheses about social process and for understanding how historical-ecological *landscapes* and *totalities* change through time (*sensu* Crumley 1994:5; Patterson 1994:223–237). We present a locally focused paleoecological reconstruction that provides signatures for

climatic conditions (i.e., temperature, precipitation, storm activity, etc.), sea-level oscillations, and human influence across the first millennium AD at the Crystal River site (8CI1)—a village and civic-ceremonial center on Florida's west-central coast (Pluckhahn and Thompson 2010, 2014, 2018). To track these socioecological processes, we reconstruct vegetation histories through stratigraphic analysis of pollen grains, fern spores, and siliceous microfossils preserved within marsh peat, hammock soils, and shell midden deposits.

Plant microfossil assemblages are particularly informative for historical ecological work because plant communities, and particularly wetland plant communities, respond readily to changes in temperature, hydrology, topography, salinity, fire frequency, nutrient availability, and other factors (Kelly and Goulden 2008; Tiner 1999). When interpreted through an archaeological lens, vegetation histories offer valuable records of human influence on past landscapes (e.g., Delcourt and Delcourt 2004; McLauchlan 2003; Scharf 2010). Indeed, a critical mass of archaeologists, ecologists, and earth system scientists now accept that ecological processes cannot be properly understood without studying the complex ways human groups reshape natural systems on various temporal and spatial scales (Braje 2015).

Marine shell middens are complex depositional environments, and the palynology of these anthropogenic structures is a fledgling area of research (see Kelso et al. 2000). While organic-rich "black-earth" strata are likely to yield relatively good plant microfossil preservation, dense layers of "clean shell" and quartz-sand deposits pose particular challenges. As such, different strata analyzed for this study exhibited variable pollen recovery, and our results—while significant—should be treated as preliminary.

To develop a more robust, landscape-scale, history of the marsh-dominated coastal zone encompassing the Crystal River drainage, we tie our reconstruction into findings from local studies of paleoprecipitation (Van Beynen et al. 2008) and

geomorphology (Goodbred et al. 1998; Hine et al. 1988; Hutton 1986; Wright et al. 2005) from Wacasassa Bay on Florida's Big Bend Coast (Figure 1). To put the record from the Crystal River drainage into a broader regional perspective, we contrast our reconstruction with: sea-level proxies from Southwest Florida and the panhandle (Stapor et al. 1991; Tanner 1991, 1992), stable isotope-derived reconstructions of Southwest Florida sea level and climate (Walker and Surge 2006; Wang et al. 2011, 2013), and an averaged sea-level oscillation model for the Gulf Coast (Balsillie and Donoghue 2004). Additionally, we contextualize the climate signatures apparent in our dataset within large-scale late-Holocene climate patterns documented at widely distributed global locales (reviewed succinctly by Little 2003).

## THE CRYSTAL RIVER SITE

The Crystal River site lies within the Big Bend region of Florida's Gulf Coast, 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 Mesozoic/early Cenozoic shallow-water carbonate platform. The broadness and low-gradient of the drowned continental shelf in this region, along with a paucity of siliciclastic sediment supply combine to produce an exceptionally low-energy coastline without the barrier island-lagoon systems that dominate coastal regions to the south and along the Florida panhandle (Tanner 1960).

The open marsh ecosystems of Florida's Big Bend Coast exhibit distinctive spatial patterning influenced by elevation and salinity (Hutton 1986) (Figure 2). 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
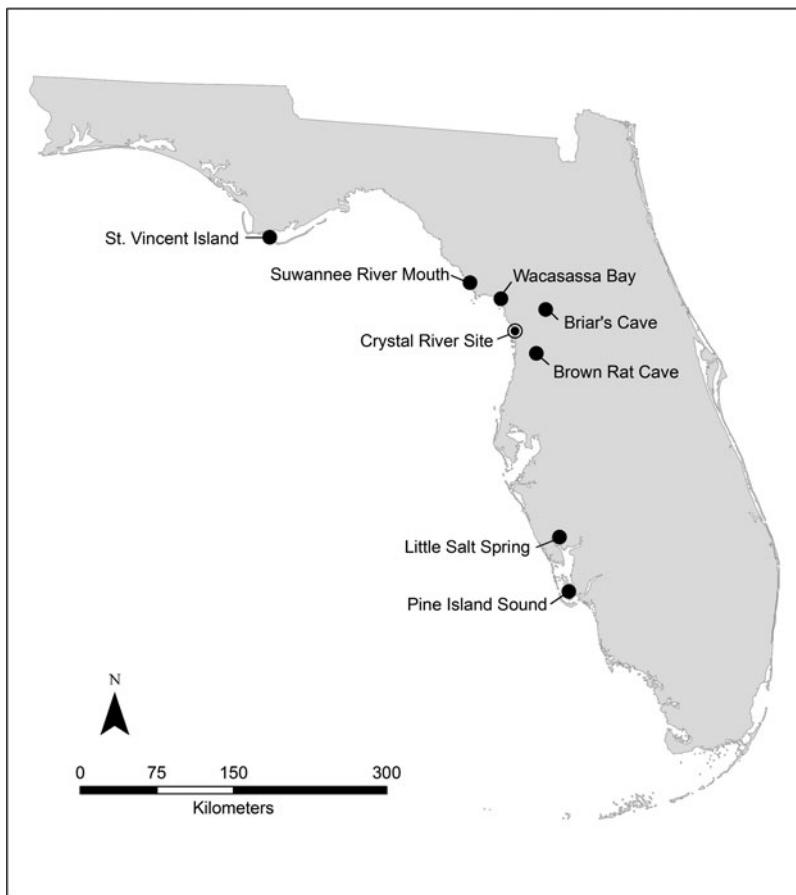
**Figure 1.** *Locations of research sites mentioned in this paper.*

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. Closer to the open gulf, nearly homogenous swaths of *Juncus romerianus* form broad salt marshes fringed by *Spartina alternaflora*. The marshes are dotted with hammock islands, which sit on topographic highs in the limestone substrate. Like the marshes, hammock vegetation is spatially patterned according to marine influence. The least-haline hammocks support the greatest richness of arboreal 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. The predominant trees of more-haline hammock islands are *Quercus virginiana*, *J. silicicola*, and *Sabal palmetto*. *Q. virginiana* are least salt tolerant and die out first as hammocks are transgressed by rising sea level; *J. silicicola* tolerate relatively saline niches; and the *S. palmetto* is most salt tolerant—dying out only once drowned by near perennial inundation by sea water (Vince et al. 1989; Williams et al. 1999).

The Crystal River mound complex sits on the northern bank of the Crystal River about midway along its short 9 km run and roughly a kilometer upstream from where the river divides into a maze of smaller
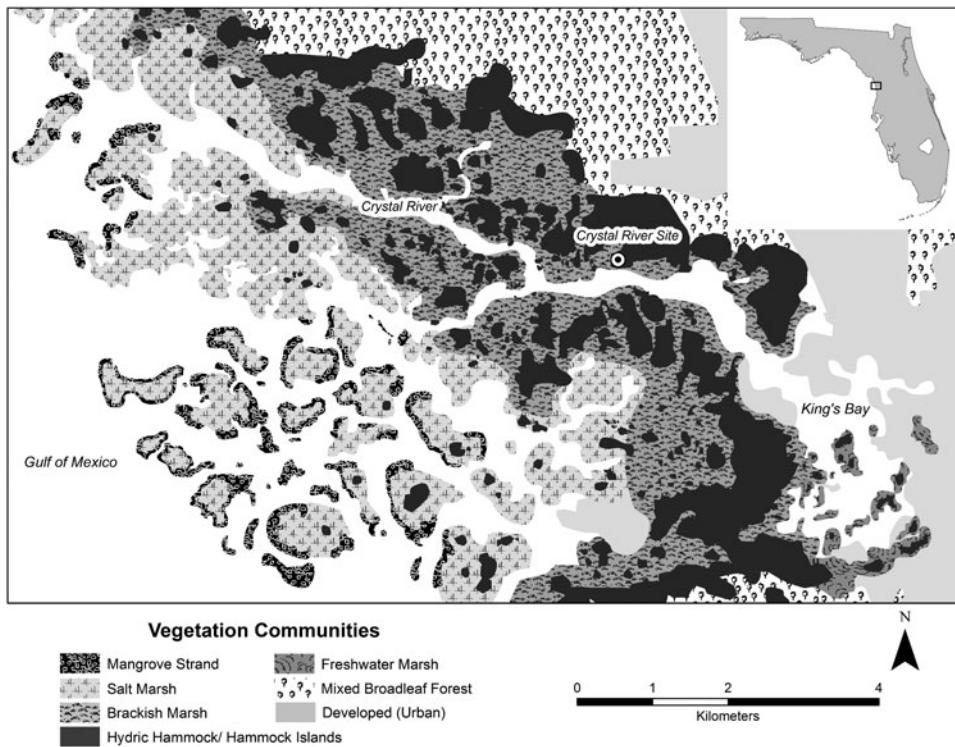
**Figure 2.** *Generalized vegetation map of the Crystal River drainage.*

channels separated by marsh and hammock islands. Crystal River site became famous among archaeologists in the early twentieth century after C. B. Moore excavated the site's two burial mounds, producing hundreds of ornaments manufactured from extra-local raw materials (i.e., copper, silver, and quartz crystals) (Moore 1903, 1907, 1918). Fifty years after Moore's first investigations, Bullen (1953, 1966) discovered a large section of midden and two mounds not recorded by Moore. Unfortunately, while Bullen excavated in the midden and portions of two burial mounds, his work—like Moore's before him—is poorly documented. Over the past 10 years, the Crystal River Early Villages Archaeological Project (CREVAP) has employed modern technology and conservative sampling to reconstruct the site's occupational history and the chronology of mound construction (Pluckhahn and Thompson 2018; Pluckhahn et al. 2015). This study builds upon a growing collection of CREVAP-facilitated research integrating geophysical, ecological, and techno-social analyses (Duke 2015; Lulewicz et al. 2017; O'Neal 2016; Pluckhahn and Thompson 2017; Pluckhahn et al. 2015; Thompson et al. 2015).

Recent research suggests coastal foragers may have begun constructing the sand and shell earthworks that comprise the Crystal River site as early as the eighth century BC (Pluckhahn and Thompson 2017, 2018). However, early dates from the burial mounds are potentially complicated by marine reservoir effects, and it seems safest to assume that a vacant ceremonial center had developed by at least 200 BC. People began living at the site in the first century AD, perhaps seasonally at first but soon more permanently and in larger numbers (Lulewicz et al. 2017; Pluckhahn and Thompson
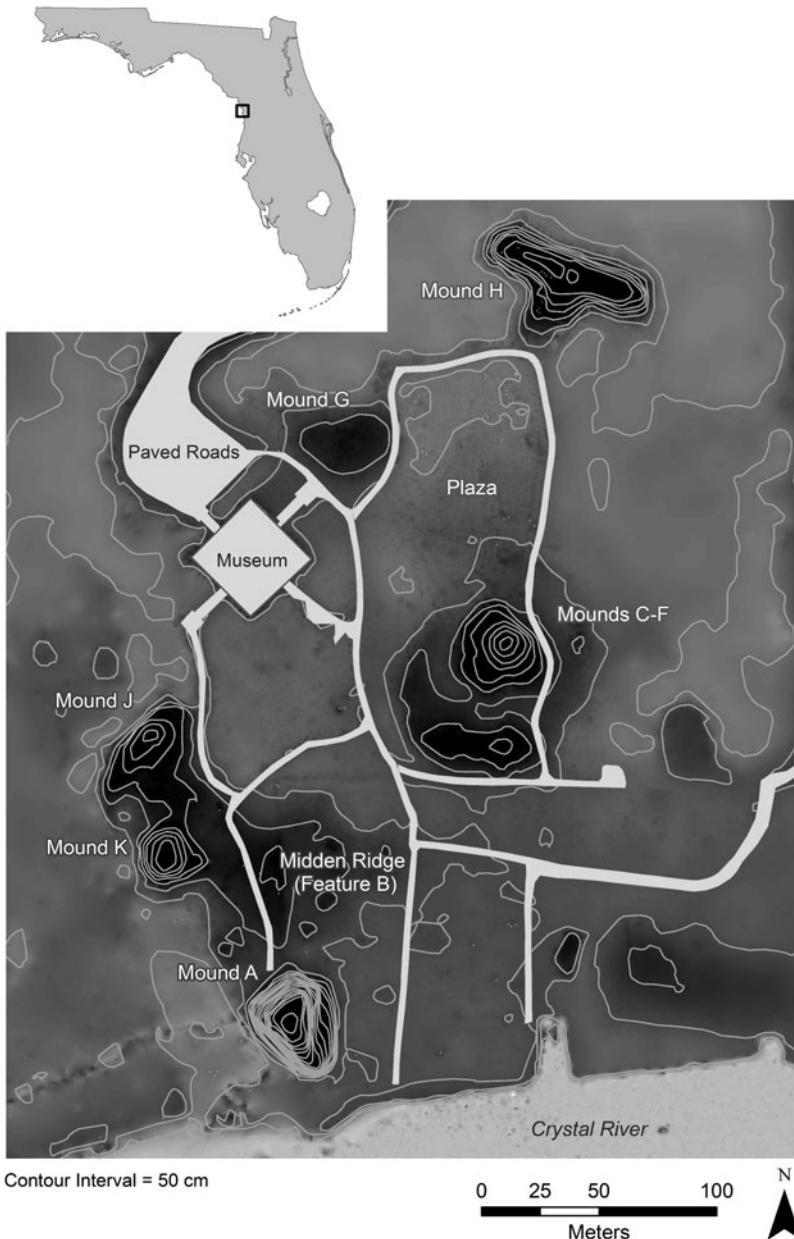
***Figure 3.*** *Topographic plan map of the Crystal River site.*

2018; Thompson et al. 2015). Over a millennium of 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 ca. AD 800—the complex contained two mounded mortuaries, two platform mounds, a well-defined plaza, and a deeply stratified shell ridge/midden feature (Figure 3). More than 30 recent

**Table 1.** **Bayesian phase date ranges for occupation at 8CI1, adapted from Pluckhahn et al. 2015.**

| | Modeled 1σ Ranges (*cal AD*) | | Modeled 2σ Ranges (*cal AD*) | |
|---|---|---|---|---|
| **Phase** | **Start** | **End** | **Start** | **End** |
| 1 | *125–199* | *180–242* | *69–225* | *144–265* |
| 2 | *238–292* | *441–499* | *221–321* | *434–544* |
| 3 | *521–605* | *671–747* | *478–634* | *663–810* |
| 4 | *779–867* | *902–982* | *723–881* | *891–1060* |

radiocarbon dates obtained from trench excavations into the midden ridge and coring in the platform mounds enabled Pluckhahn and colleagues (Pluckhahn and Thompson 2017; Pluckhahn et al. 2015) to develop a Bayesian statistical model for the chronology of site construction and occupation. Below, phase date ranges reference the 95 percent probability distributions of modeled start and end dates. We use italics to distinguish modeled date ranges from simple calibrated dates. The phase modeling divides domestic occupation into four phases, with Phase 2 (*ca. AD 221–544*) representing the florescence of occupational activity. We rely upon these phase designations (Table 1) for chronological control of localized midden stratigraphy, as well as for comparing socioecological signatures with occupational history.

## METHODS

In the summer of 2011 a CREVAP field school team collected 58 sediment cores from village features and adjacent wetland areas (see Norman 2014; Pluckhahn et al. 2015). Midden ridge and mound cores were collected with a Geoprobe Model 6620DT hydraulic coring system capable of taking multiple core sections, each about 115 cm long and 4.5 cm in diameter. One-meter-long, single-section cores of the same diameter were retrieved from marsh and hammock soils adjacent to the site using a Vibracore system. Three cores from ideal depositional contexts displayed good-to-fair microfossil preservation and were

selected for palynological analysis. These included: one core from a well-preserved section of the midden ridge (Core 11), one core from the brackish tidal marsh lying just southwest of the midden ridge (Core 48), and one core from the hydric hammock east of the Plaza (Core 55) (Figure 4). To establish chronological control of the wetland cores, radiocarbon samples were collected from select core strata and submitted for analysis to the Center for Applied Isotope Studies at the University of Georgia. Core 11 was collected directly adjacent to Trench 1, from which Pluckhahn and colleagues (2015) base their midden phase chronology (Table 1).

Cores were divided stratigraphically, sampled, and stored for later analysis by Norman (2014). Because of the original stratigraphic sampling strategy our analytical intervals here are variable and generally coarser than is typical for palynological work. To yield averaged representative microfossil sub-samples, we homogenized each stratigraphic sample before sub-sampling. Sub-samples from each stratum of the three cores were processed to concentrate fossil pollen, spores, and siliceous microfossils. It should be noted that sediment accumulation in the midden context was clearly punctuated such that even at coarse depth intervals the record is of reasonable chronological resolution for preliminary work. Laboratory procedures followed Faegri and colleagues (1989) and were designed to account for abundant $CaCO_3$, charcoal, and sand (Jackson 2016:161–162). We found heavy-liquid
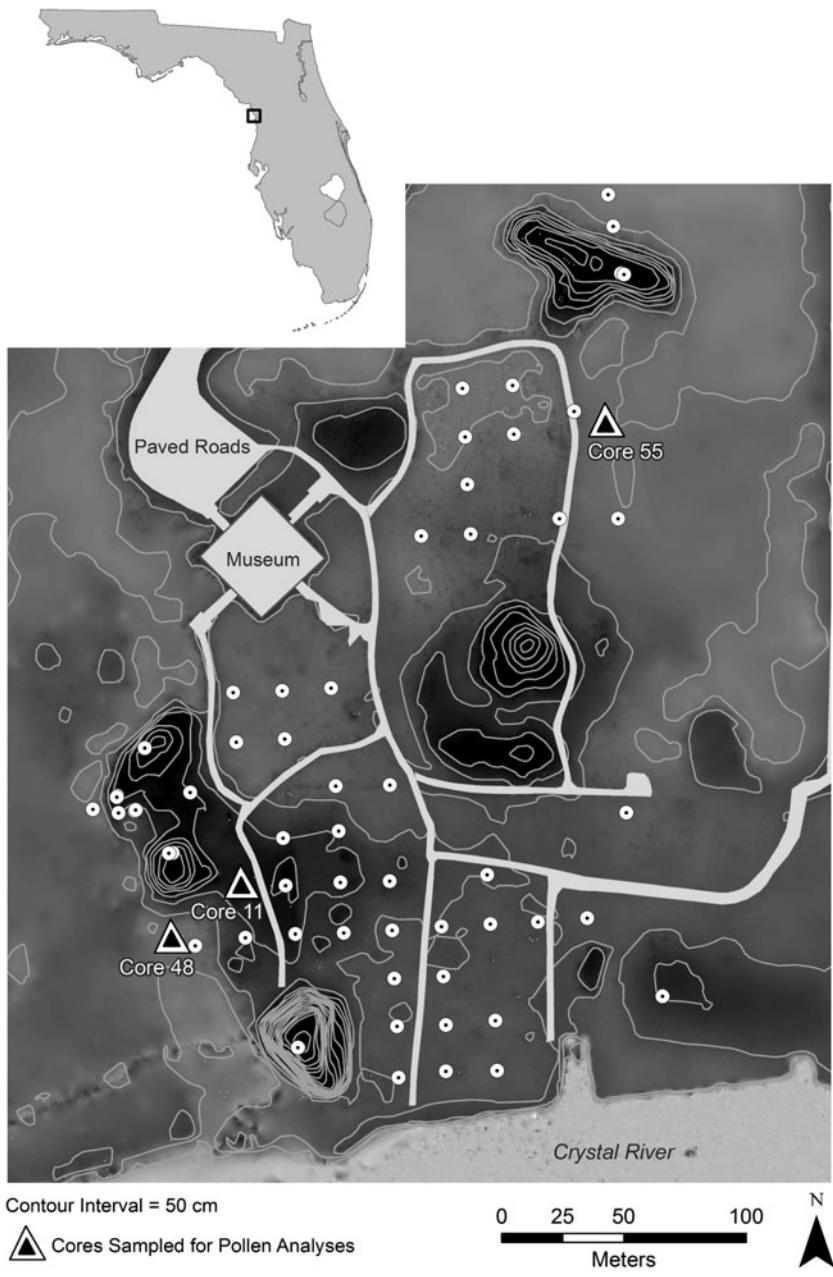
**Figure 4.** *Coring locations at Crystal River site.*

separation via saturated $ZnCl_2$ solution particularly useful in this regard. Due to the preliminary nature of our study, our preparations did not involve tracer spores or microspheres, and extrapolated values for microfossil concentration were not calculated. Taxonomic identifications and counts were made along transects under a compound microscope working between 400 and $1000\times$ magnification. Identifications

were cross-checked with modern comparative collection specimens and regional identification keys (Kapp 1969; Willard et al. 2004). Count data were imported into the Tilia 2.0.4.1 software package for statistical analyses and diagram production (©1991–2015 Eric Grimm). Constrained Incremental Sum of Squares (CONISS) cluster analyses were run for cores 11 and 55 in order to group stratigraphic samples into zones. The CONISS included square root transformations and utilized Edwards and Cavalli-Sforza's Chord Distance as a dissimilarity coefficient, which treats populations as points within a D-dimensional Euclidean space (Grimm 1987).

## RESULTS

### The Midden (Core 11)

The midden stratigraphy captured within Core 11 exhibits an alternating pattern of black-earth soil formation followed by shell deposition (Jackson 2016:65–67). This stratigraphy corresponds well with that of Trench 1 and enables us to apply Pluckhahn and colleagues' (2015) Bayesian chronological model to the core strata analyzed here (Table 1). A carbon sample from a thin basal soil (Stratum 11) yielded a two-sigma calibrated AMS date of 2620–2475 BC (Table 2). The sand strata lying atop this thin soil and below the midden deposits have not been directly dated but may be tentatively associated with the last two millennia BC and/or the first century AD. Among Core 11 samples, pollen preservation was best within charcoal-rich, black-earth midden layers (Strata 4, 5, and 7),

and was also generally good within Stratum 11 (Table 3). Shell-rich midden layers (Strata 2, 3, and 6) yielded less robust, yet informative, pollen counts. As expected, the sand strata displayed very poor and/or highly selective preservation and have been excluded from our study.

The pollen diagram for Core 11 (Figure 5) displays percent composition data for the most frequent plant taxa represented within the pollen assemblage and includes a schematic of core stratigraphy as well as chronological associations. Five ecological zones were identified via CONISS cluster analysis; we utilize these zones below to organize and report our findings within Table 4.

### The Riverside Marsh (Core 48)

The soil profile in Core 48 matches the dark brown-to-black peaty-mud facies described by Goodbred and colleagues (1998) and Hine and colleagues (1988). These deposits are characteristic of Florida's Big Bend Coast Marshes and form largely through partial decomposition of marsh plants. Stratum 1 (0–46 cm) is composed entirely of marsh peat and was sampled by Norman (2014) as a single stratigraphic unit. As noted above, we homogenized the sample before sub-sampling in an attempt to yield a representative (if low-resolution) picture of vegetation composition as preserved within this stratum. Stratum 2 (46–52 cm) contains a conspicuous quantity of fragmentary shell, fish bone, and charred plant material. This stratum has no suitable correlate in the regional geological literature and very likely formed via

*Table 2.* **Radiocarbon dates from select core samples at Crystal River.**

| Core | Stratum | Sample ID | Material | δ13C, | Radiocarbon Age (BP) | Calibrated Date 2σ (IntCal 13) |
|------|---------|-----------|----------|-------|----------------------|-------------------------------|
| 48 | 2 | 8CI1SS1153C | charcoal | −25.2 | 1380 ± 20 | AD 625–671 |
| 55 | 6 | 8CI1SS1176C | charcoal | −24.9 | 1130 ± 20 | AD 878–982 |
| 55 | 2 | 8CI1SS1172C | charcoal | −26.8 | 360 ± 25 | AD 1452–1634 |
| 11 | 11 | 8CI1SS515C | soil carbon | −27.7 | 4030 ± 25 | 2620–2475 BC |

*Table 3.* **Pollen count data for cores 11, 48, and 55.**

| Sample | Ecological Zone | Preliminary Pollen Count (n=) |
|---|---|---|
| Core 11 | | |
| Str 1 (0–6 cm) | 1 | 52 |
| Str 2 (6–24 cm) | | 56 |
| Str 3 (24–37 cm) | 2 | 33 |
| Str 4 (37–47 cm) | | 81 |
| Str 5 (47–58 cm) | 3 | 109 |
| Str 6 (58–72 cm) | | 60 |
| Str 7 (72–108 cm) | 4 | 116 |
| Str 11 (158–160 cm) | 5 | 215 |
| Core 48 | | |
| Str 1 (0–46 cm) | — | 156 |
| Str 2 (46–52 cm) | — | 117 |
| Core 55 | | |
| Str 1 (0–12 cm) | 1 | 136 |
| Str 2 (12–18 cm) | | 180 |
| Str 3 (18–22 cm) | 2 | 330 |
| Str 4 (22–32 cm) | | 118 |
| Str 5 (32–44 cm) | 3 | 102 |
| Str 6 (44–52 cm) | | 209 |

deposition or *ex situ* transport of midden materials. A limited auger survey in 1993 also located buried midden deposits extending to approximately 210 cm in the riverbank marshes (Weisman 1995). Correcting for the compaction inherent in Vibracore sampling, the midden strata captured in Core 48 appear to rest below about a meter of peat. A charcoal sample from Stratum 2 yielded a two-sigma calibrated date range of AD 620 to 680 (Table 2). The strategy used to originally sample Core 48 (Norman 2014) precludes the utility of chronometrically dating Stratum 1. However, the date on Stratum 2 provides a probable *terminus post quem* for the deposition of marsh peat atop riverbank midden, likely transpiring through the ninth and tenth centuries AD. Both marsh core strata displayed relatively good pollen preservation.

Figure 6 displays the percent composition data for the most frequent taxa identified within Core 48. A CONISS cluster analysis and the identification of zones, as done for Core 11 and Core 55 (below) would be inappropriate here as only two samples were analyzed. However, clear differences in pollen assemblages between the two strata speak to notable environmental changes (Table 5).

## The Hydric Hammock (Core 55)

Core 55 contains clearly discernable soil horizons, including an apparent buried A-horizon. We note that Core 55 did not encounter limestone bedrock or eroded limestone material, and substantial sediment deposits may underlie the basal stratum analyzed here. Pollen preservation in Core 55 is generally good, particularly in organic-rich soil horizons (Strata 1, 2, 3, and 6) (Table 3). A soil carbon sample from Stratum 6 (44–52 cm) yielded a calibrated date range of AD 880 to 990 (Table 2),
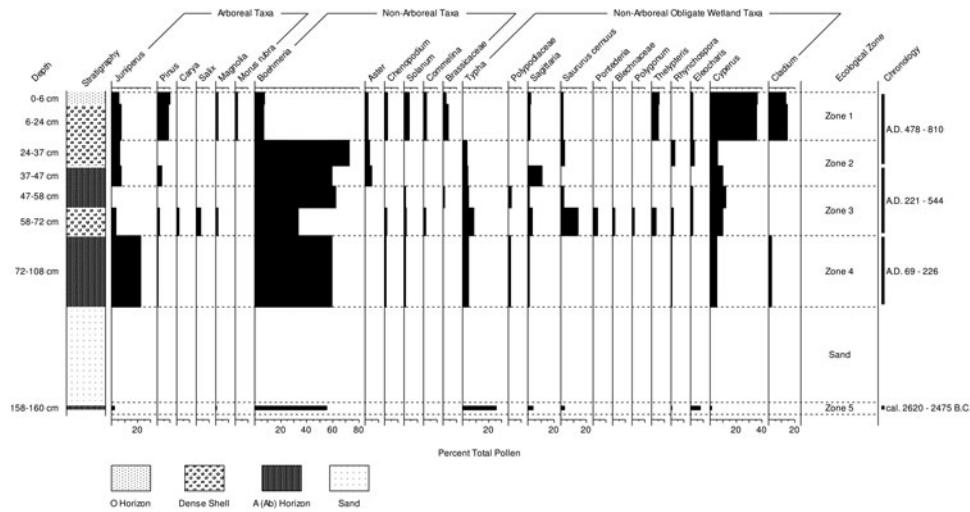
**Figure 5.** Core 11 *pollen diagram.*

falling within Phase 4, the final few centuries of site use at Crystal River (Pluckhahn et al. 2015). A soil carbon sample from Stratum 2 (12–18 cm) returned a calibrated date range of AD 1450 to 1630.

The pollen diagram for Core 55 (Figure 7) displays percent composition data for the most frequent taxa; the CONISS cluster analysis suggests the presence of three distinct ecological zones, each composed of two strata (Jackson 2016:fig. 5.8). Table 6 reports a summary of Core 55 results organized by zone.

### DISCUSSION—A LANDSCAPE IN FLUX

This preliminary pollen record from midden and wetland soils at Crystal River conveys patterned diachronic variation in the composition of local plant communities. In the following discussion, we draw upon the record from Crystal River site to develop a tentative landscape reconstruction for the first millennium AD. The pollen assemblages recovered from deposits at Crystal River site most likely represent a proximal catchment area extending perhaps a kilometer from the mound center, though pollen from certain anemophilous taxa (i.e., Juniperus silicicola) may represent

a larger catchment area radius extending several kilometers. To contextualize our interpretations, we draw attention to complimentary and contrasting paleoenvironmental records from local, regional, and extra-regional loci.

### Marine Transgression and the Changing Role of Crystal River Site

During the first three centuries AD local communities at Crystal River constructed Mound J and deposited great volumes of shell and other midden materials to form an abbreviated comma-shaped ridge along the riverbank (Pluckhahn and Thompson 2018; Pluckhahn et al. 2015). These developments represent the transformation of the site from a presumably "vacant" mortuary/ceremonial center to a habitation site and civic node of the landscape. This pattern has also been observed farther north, near the mouth of the Suwannee River, where coastal forager communities also resettled elevated landforms inland from the Gulf Shore during this time and began constructing large-scale shellworks (McFadden 2015, 2016; Sassaman et al. 2014; Wallis et al. 2015).

*Table 4.* Palynological results summary from Core 11.

| "Ecological Zone" | Stratigraphy | Assoc. Date Range | Results Summary |
|---|---|---|---|
| 5 | Stratum 11 (158–160 cmbs) | cal 2620–2475 BC | • AP* limited to small quantities of *J. silicicola*, *Magnolia* spp. and *Ulmaceae*.<br>• NAP* and NAOWP* dominated by *B. cylindrica* and *Typha* spp., with *Eleocharis* spp., *Sagittaria* spp., *S. cernuus*, and *Cyperus* spp. also present.<br>• Freshwater wetlands (marsh-dominated). |
| *Sand* | Strata 8, 9, 10 (108–158 cmbs) | ca. 2475 BC–AD 69 | As expected, sand deposit(s) yielded almost no identifiable microfossils. Given the nature of the local siliciclastic sediment supply and transportation processes, these deposits were likely laid down by a series of storm-surge events. |
| 4 | Stratum 7 (72–108 cmbs) | ca. *cal AD 69–226* | • *J. silicicola* relatively abundant given sparse AP representation. Palm phytoliths abound (42.1% of total microfossils).<br>• NAP and NAOWP dominated by *B. cylindrica* and sedges (*C. mariscus*, *Rhynchospora* spp., and *Cyperus* spp.).<br>• Previously abundant freshwater-dependent wetland forbs are absent.<br>• Major expansion of brackish marsh and hydric hammock. |
| 3 | Strata 5 and 6 (47–72 cmbs) | ca. *cal AD 221–544* | • AP assemblage is taxonomically rich, if numerically weak, including *J. silicicola*, *S. caroliniana*, *Carya* spp., *Magnolia* spp., and *Pinus* spp.<br>• NAP diversified to include various warmth- and precipitation-loving, disturbance marker taxa: *Smilax* spp, *Chenopodium* spp., *S. americanum*, Brassicaceae, *Commelina* spp., and Poaceae.<br>• Among NAOWP, *S. cernuus* is especially abundant; *P. cordata*, *Rhynchospora* spp., and *Sagittaria* spp. also represented.<br>• Previously cedar-dominated haline niches opened up to support new arboreal taxa with lesser salt-tolerance. Freshwater wetlands were locally present and maintained some separation from tidally influenced brackish river marshes. |
| 2 | Strata 3 and 4 (24–47 cmbs) | ca. *cal AD 478–810* | • AP limited; *Carya*, *Salix, and Magnolia* absent. |

*(Continued)*

**Table 4. (Continued).**

| "Ecological Zone" | Stratigraphy | Assoc. Date Range | Results Summary |
|---|---|---|---|
| | | | • NAP dominated by *B. cylindrica*; warmth- and precipitation-loving weedy taxa absent. |
| | | | • NAOW forbs also drop out, with only *Sagittaria* spp., *Typha* spp., and small percentages of generalist sedges (*Eleocharis* spp. and *Cyperus* spp.) represented. |
| | | | • Reduction in the prevalence of well-preserved pollen grains, reduced taxonomic richness, and the dominance of generalist plants that tolerate wide swings in temperature and precipitation frequency. |
| 1 | Strata 1 and 2 (0–24 cmbs) | | • AP shows *J. silicicola* increase; *Pinus* spp., *Magnolia* spp., and *Morus rubra* present. |
| | | | • NAP shows decreasing *B. cylindrica*, and expansion of *Brassicaceae, S. americanum, Chenopodium* spp. |
| | | | • NAOWP dominated by *Cyperus* spp. and *C. mariscus*; *Sagittaria* spp. and *S. cernuus* present. |
| | | | • Increasingly brackish marshes dominated the river bank wetlands near the site; freshwater wetlands also locally present. |

* AP = Arboreal Pollen; NAP = Non-Arboreal Pollen; NAOWP = Non-Arboreal Obligate Wetland Pollen.
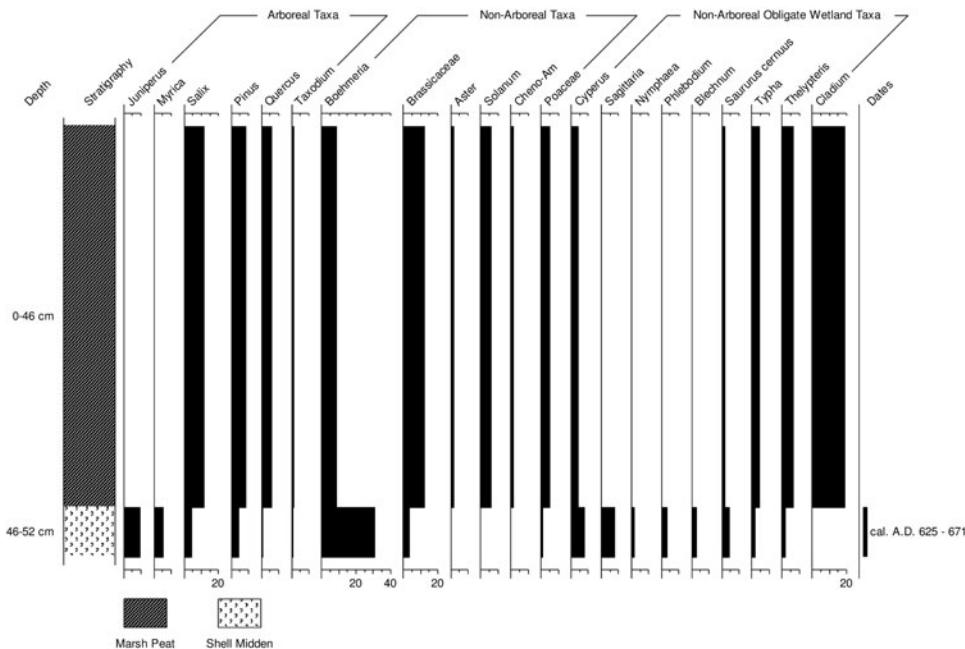
***Figure 6.*** Core 48 *pollen diagram.*

The historical gravity of these coastal mortuaries must have factored heavily into the subsequent intensification of mound construction and civic-ceremonial activity over the first millennium AD. However, contemporaneous ecological shifts described below likely played an influential role in settlement patterning by enabling both upstream relocation and population nucleation within coastal drainages.

The earliest palynological records from Crystal River site (Core 11, Zones 5 and 4) suggest that a major ecological transition occurred in the century preceding incipient midden deposition (ca. *AD 65–265*). This transition witnessed extensive sand mobilization (perhaps via storm events) and the replacement of freshwater wetlands by brackish marsh and salt-tolerant tree stands. A lack of chronometric data from Core 11 sand deposits limits our ability to empirically explain the duration and tempo of this ecological shift. However, geomorphological studies from nearby Wacasassa Bay suggest that this sub-region experienced a relatively rapid transgressive

sea-level event at the onset of the first century AD (Goodbred et al. 1998; Hine et al. 1988). This event, transpiring between cal 21 BC and AD 331 forced tidal waters perhaps two kilometers inland, transforming freshwater wetlands into expanses of brackish marsh (also see Hutton 1986 and Wright et al. 2005). Notably, Goodbred and colleagues (1998) hold that this transgressive pulse, while powerfully transformative, did not exceed modern mean sea level (MSL), though storm surges very likely did.

Analyses of beach ridges in Charlotte Harbor/Pine Island Sound led Stapor and colleagues (1991:835) to propose that the turn of the millennium was characterized by transgressive seas, rising in Southwest Florida to perhaps 1.2 m above MSL. A "seven-point floating average" sea-level curve for the Gulf Coast produced by Balsillie and Donoghue (2004:14), and Tanner's (1992) analysis of beach ridges on St. Vincent Island report results similar to those of Stapor and colleagues (1991). Walker and colleagues (1995:215) propose a more recent occurrence for this high

*Table 5.* **Palynological results summary from Core 48.**

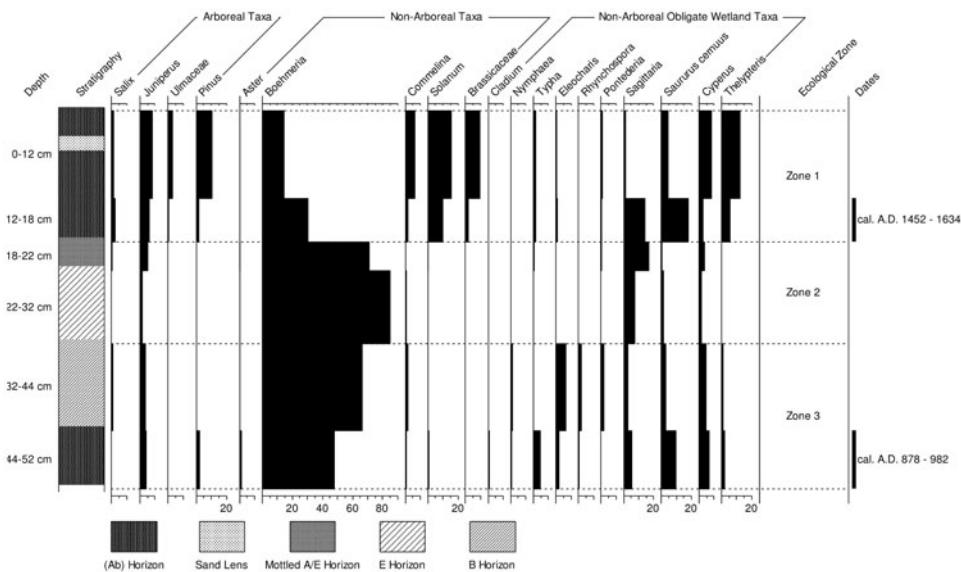| Stratigraphy | Assoc. Date Range | Results Summary |
|---|---|---|
| Stratum 2 (46–52 cmbs) | cal AD 625–671 to Present | • AP dominated by *J. silicicola*; *M. cerifera*, *S. caroliniana*, and *Pinus* spp. also well represented.<br>• NAP dominated by *B. cylindrica*; small quantities of *Brassicaceae* and *Zamia* spp.<br>• NAOWP contains *Cyperus* spp., *Sagittaria* spp., various ferns, *S. cernuus*, and *Typha* spp.<br>• Oligohaline river-bank marshes with *J. silicicola*, *M. cerifera*, *Quercus* spp., along the hammock-marsh interface; freshwater Wetlands also locally present. |
| Stratum 1 (0–46 cmbs) | cal AD 625–671 | • AP shift to *S. caroliniana*, *Pinus* spp., and *Quercus* spp.<br>• NAP shows *B. cylindrica* decrease; increase in *Brassicaceae, S. americanum, Poaceae*.<br>• In NAOWP, freshwater-dependent taxa were replaced by oligohaline marsh plants, particularly *C. mariscus*, but also *Typha* spp.<br>• In comparison with Stratum 2, the data suggest that lower elevation midden areas at Crystal River site were transgressed sometime after ca. AD 671, enabling the formation of the dense brackish marsh peat deposits that make up Stratum 1. |



*Figure 7.* Core 55 *pollen diagram.*

*Table 6.* **Palynological results summary from Core 55.**

| Pollen Zone | Stratigraphy | Assoc. Date Range | Results Summary |
|---|---|---|---|
| 3 | Strata 5 and 6 (32–52 cmbs) | cal AD 878–982 | • AP limited to *J. silicicola*; minor presence of *S. caroliniana*, *M. rubra*, and *Pinus* spp. <br> • NAP exhibited low richness, dominated by *B. cylindrica*. <br> • NAOWP is taxonomically rich, including; *Eleocharis* spp., *Cyperus* spp., *Sagittaria* spp., *S. cernuus*, *Rhynchospora* spp., *Nymphea* spp., and ferns. <br> • Wetlands adjacent to the site experienced substantial tidal influence in the tenth and perhaps eleventh centuries AD; freshwater wetlands also present. |
| 2 | Strata 3 and 4 (18–32 cmbs) | — | • AP assemblage changed little from the preceding strata. <br> • NAP assemblage also similar to above. <br> • NAOWP assemblage changed substantially, indicating expansion of *Sagittaria* spp. *S. cernuus* and *P. cordata* declined, and freshwater sedges drop out. <br> • This pattern accentuates the ability of *Sagittaria* spp. to proliferate under conditions adverse to other wetland forbs, most notably periods of drought and/or fluctuating temperatures. |
| 1 | Strata 1 and 2 (0–18 cmbs) | cal AD 1452–1634 | • AP shows increased richness: *Pinus* spp., *J. silicicola*, *Ulmaceae*, *S. caroliniana*, *M. rubra*, and *Quercus* spp. <br> • The NAP assemblage also diversified: *S. americanum*, *Brassicaceae*, *Commelina* spp., *Mimosa pudica*, and *B. cylindrica*. <br> • Little NAOWP change: *Eleocharis* spp. and *P. cordata* reappear; *Typha* spp. and *Cyperus* spp. increased in relative abundance; *S. cernuus* and ferns proliferated. <br> • Development of the extant freshwater swamp/hydric hammock community. |

stand, suggesting a rise to modern MSL between AD 150 and 250 and continued sea-level rise to 70–137 cm above modern MSL between AD 250 and 550. Notably, transgressive seas have also been documented at this time on the South Carolina coast (Brooks et al. 1989:94), as well as at various sites along the European Atlantic coast (Crumley 1987:240; Lamb 1995:162–165; Ters 1987:227).

It is difficult to say to what extent the transgressive pulse between cal 21 BC and AD 331 motivated people to intensify mound construction and initiate occupation at Crystal River site. However, it seems unlikely that these contemporaneous cultural and environmental transformations were unconnected. If we assume that fisher-hunter-gatherer communities inhabiting the drainage selected civic and ceremonial nodes based on the physical location of major ecotones (especially those favorable to oyster, mixed fresh-brackish marsh, and forested hammocks), then it is 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 BC/first centuries AD.

## The Roman Optimum and the Florescence of Crystal River Site

The pollen data from Zone 3 of Core 11 (ca. *cal AD 221–544*) generally suggest increased precipitation frequency, wetland development, and warmth. The reduced prevalence of *J. silicicola* pollen suggests that previously haline hammock niches opened up to less salt-tolerant tree species that appear at this time in the pollen record. Freshwater wetland forbs are represented, as are brackish marsh plants, perhaps attesting to slowed but continuing coastal transgression in the centuries following the transgressive pulse (ca. cal 21 BC–AD 331) described above. Notably, the pollen record from Zone 3, Core 11 does not show clear evidence for the greater-than-present MSL reported from Southwest

Florida and St. Vincent Island (Stapor et al. 1991; Tanner 1991, 1992; Walker 2013; Walker et al. 1995). Goodbred and colleagues (1998) cite extensive development of brackish marsh and oyster bioherms as evidence of increasing coastal stability after the first few centuries AD. Increased precipitation is also indicated by paleoprecipitation reconstructions developed from the analysis of speleothems from nearby limestone cave systems: Brown Rat Cave and Briars Cave (Van Beynen et al. 2008). Their reconstruction, which corresponds well with data from Little Salt Spring (Zarikian et al. 2005), proposes that the period from ca. AD 200 to 600 brought increased precipitation. Palynological data from the central lakes region of Florida (Watts 1980) also indicate wetland expansion in the first several centuries AD, likely brought about by a combination of rising sea level (and thus rising water tables) and increased precipitation. At a broader climatic scale, the interval between the last century BC and ca. AD 600 is known as the Roman Optimum (RO), characterized by relatively warm and wet climate and transgressive seas. The Phase 2 deposits at Crystal River site fall securely within this time period, and the pollen data substantiate the local manifestation of RO conditions.

The Phase 2 midden samples (Core 11, Zones 2 and 3) contain palynological evidence that people intensified midden and mound building activities during the RO. Disturbance marker species fond of warm and wet conditions appear in the NAP (*Smilax* spp., *Solanum americanum.*, *Brassicaceae*, *Commelina* spp.) and AP (*Salix caroliniana.*) assemblages. As relatively short-statured, zoophilous plants, it is likely that the NAP disturbance-related taxa grew atop the midden itself. If this was the case, we can imagine the midden ridge well above mean high tide and maintained in an incipient successional state, as would be expected given perennial or near perennial habitation/activity. The proliferation of *S. caroliniana* also supports the operation of a precipitation-heavy climatic regime and suggests that wetland areas near the site experienced substantial disturbance

(e.g., vegetation harvesting, clearing, burning). The increased abundance of *Typha* spp. through the early and middle portions of Phase 2 also indicates intensive site use. *Typha* spp. outcompete other emergent marsh taxa (particularly *Cladium mariscus*) when nutrient levels are elevated (Newman et al. 1996), and high *Typha* spp. prevalence and unexpectedly low *C. mariscus* pollen frequency during Phase 2 may have resulted from localized anthropogenic nutrient-loading. The pollen data are consistent with midden accumulation-rates and oyster-shell geochemistry from Phase 2 contexts at Crystal River that suggest intensified terraforming and perennial habitation (Pluckhahn et al. 2015; Thompson et al. 2015).

## The Vandal Minimum: Crystal River Wanes, Roberts Island Rises

Pluckhahn and colleagues (2015) reconstruct Phase 3 (*ca. AD 478–810*) at Crystal River site as a period of sociocultural transformation, where habitation—and perhaps also mound construction—waned. Much of the population appears to have shifted downstream to the Roberts Island mound complex, which soon supplanted Crystal River as the major ceremonial center within the drainage. In the Suwannee River mouth region, Sassaman and colleagues (2014) have documented the occupation of lower-elevation, seaward hammock islands around this time extending until ca. AD 850 (Borremans 1991). Indeed, at mound centers north and south of Crystal River site on the Florida Gulf Coast (e.g., Austin et al. 2014; Russo et al. 2014; Wallis et al. 2015) and at prominent mound centers of the southeastern coastal plain (e.g., Pluckhahn et al. 2018) the interval between ca. AD 600–850 witnessed massive community reorganizations suggestive of widespread, coupled socioecological disruptions.

Zone 2 of Core 11 aligns stratigraphically with the terminal portion of Phase 2 (ca. *cal AD 221–544*) and the nascent portion of Phase 3 (ca. *cal AD 478–809*). The pollen assemblage, while composed of lesser pollen counts, suggests reduced taxonomic richness and the persistence of generalist plants that tolerate wide swings in temperature and precipitation. Precipitation rates apparently decreased substantially within the interval ca. AD 650–800 near Briars Cave (Van Beynen et al. 2008). Contemporaneous aridity is recorded in paleoclimate data from Little Salt Spring (Zarikian et al. 2005), and these records align temporally with drought events that impacted the circum-Caribbean region (see Curtis et al. 2001; Hodell et al. 1991). Reviews of paleoclimate data from various locales throughout the Atlantic basin suggest that these conditions were part of a broad-scale cooling period referred to as the Vandal Minimum (VM) (Crowley and North 1991:95; Gunn 2000; Meese et al. 1994; Stothers 1984).

Stratum 2 of Core 48 (cal AD 620–680) falls generally within the VM but also aligns with a half-century-long episode of frequent precipitation and warmth observed in stable isotope analyses of archaeological marine shell from Southwest Florida (Wang et al. 2011, 2013). The pollen data indicate prolific growth of oligohaline river marshes and freshwater wetlands, perhaps representing a brief period of relatively optimal climate within the VM on the Florida Gulf Coast.

Neither VM-age sample from Crystal River provides evidence for a true sea-level regression, as reported from Charlotte Harbor/Pine Island Sound where sea level reportedly regressed to 50–60 cm below MSL during the "Buck Key Low" (Stapor et al. 1991; Walker et al. 1995) (also see Balsillie and Donoghue 2004). Goodbred and colleagues (1998) propose that the Big Bend Coast saw substantially decreased transgression rates but no true sea-level regression. While our data align better with this later reconstruction, the impact of climatic aridity, the apparent variability of the VM period, and preliminary-scale pollen counts available here overcomplicate a clear palynological assessment of sea-level flux during this interval at Crystal River.

Sea-level regression, or decreasing sea-level stability, offers a seemingly intuitive socionatural explanation for the dispersal and downstream reorganization of forager communities in the Big Bend during the VM. If, as argued by Duke (2015), oyster and other shellfish had become the foci of a highly structured subsistence strategy at Crystal River by ca. AD 550, then an environmental shift compromising local oyster beds (such as increased estuary salinity brought on by climatic aridity) may have played a key role in the settlement shift during the VM. It is important to keep in mind, however, that Crystal River and Roberts Island appear to have been contemporaneously occupied for several generations before domestic deposition at Crystal River ceased entirely (ca. AD 1100). In our thinking, this fact precludes the notion of rapid and deterministic sociocultural response to environmental change and implies that community reorganization during the VM proceeded via complex negotiations that were likely tied to regional sociopolitical developments unfolding across southeastern North America.

## The Medieval Optimum and Abandonment at Crystal River Site

The term *abandonment* in its colloquial sense is likely inappropriate for the Crystal River site during Phase 4 (ca. *cal AD 787–1068*), as the mound center surely remained a part of the cultural landscape in the region for generations following the cessation of depositional activities at the site. However, the general absence of archaeological deposits dating to this period and the apparent relocation of human communities to the Robert's Island mound complex a kilometer downstream suggest that Crystal River was no longer utilized for ceremony or habitation (Pluckhahn et al. 2015).

Three stratigraphic loci at Crystal River site contain pollen records indicating the return of optimal climate and continued marine transgression after ca. AD 800: Stratum 1 of Core 48, Zone 1 of Core 11, and Zone 3 of Core 55. Stratum 1 of Core 48

(0–46 cm) post-dates cal AD 620–680 and represents a brackish marsh peat deposit likely associated with increased marine influence and an elevated river stage. Weedy taxa favoring warmth and frequent rainfall are prevalent in the pollen assemblage, and brackish marshes and haline hammocks likely expanded. Zone 1 of Core 11 aligns with the terminal portion of Phase 3 (ca. *cal AD 479–809*). The pollen data here also suggest the expansion of brackish marshes and haline hammocks, with attendant weedy taxa. Van Beynen and colleagues (2008) report a period of high precipitation rates at Briars Cave between ca. AD 850 and 1350 that corresponds with similar records from Little Salt Spring (Zarikian et al. 2005), representing regional manifestations of the Medieval Optimum (MO)—a period of warm and wet climate also documented at various sites throughout the Caribbean and North Atlantic basins (Crumley 1987:240; Gunn 1994:17; Hodell et al. 1991; Lamb 1995:185). Stapor and colleagues (1991) report a contemporaneous sea-level high stand (the "La Costa High") in Charlotte Harbor/Pine Island Sound, rising to about 50 cm above MSL (also see Walker 2013; Walker et al. 1995). The pedology of Core 48 at Crystal River, as well as the palynological records from all three cores sampled here, provide evidence for the transgression of low-elevation midden and hammock areas by brackish river water during the MO. However, it is unclear whether the river stage rose to above-present levels, and the continued presence of freshwater wetlands in the immediate vicinity of Core 55 during the MO discourages this notion.

With the return of increased marine influence and stable climate during the MO/La Costa High one might expect that optimal ecological conditions would motivate forager communities to re-occupy Crystal River site. Instead, people continued to utilize Robert's Island until its decline in the twelfth century AD. Why people did not return to Crystal River is an open question with a wide array of hypothetical explanations. However, it's clear that in this case—in keeping with the history of Crystal River's ancient communities—the nature of their

response was not reactionary or determined by externally driven environmental change, but instead resulted from complex, historically contingent, socioecological processes.

## A Pollen Record for the Little Ice Age at Crystal River Site

There is no evidence that habitation at Crystal River site extended into the Little Ice Age (ca. AD 1200–1500)—a period of relatively cool and arid climate with reduced sea temperatures (Keigwin 1996; Miller et al. 2012). Nonetheless, we present our data from this period as a reference for researchers making regional comparisons or working at nearby sites with relevant periods of occupational activity. The pollen data from Zone 2 of Core 55 (associated with the time period between ca. AD 900 and 1600) suggest that the wetland areas to the east of the plaza at Crystal River site were affected by considerable coolness and aridity, with more specialized wetland obligates declining or disappearing and cold and drought tolerant generalist plants increasing in prevalence. Proxy data from Briars Cave, Little Salt Spring, and Lake Miragoane also indicate the time period between roughly AD 1350 and 1650 experienced reduced rainfall (Hodell et al. 1991; Van Beynen et al. 2008; Zarikian et al. 2005). While Walker and Surge (2006:9) do not find zooarchaeological or stable isotope evidence from Pineland for cooler temperatures during this time interval, they do note an absence of evidence for storm events, which "is consistent with cooler sea temperatures."

## CONCLUSIONS

While archaeological palynology is a still-fledgling methodological approach on the Florida Gulf Coast—and in coastal shell-bearing sites in general—we propose that fossil pollen assemblages hold tremendous potential for improving archaeological understanding of historical-ecological processes within and between ancient coastal villages.

This preliminary study, as such, faced several limitations; among them issues with: stratigraphic sampling resolution, inconsistent and occasionally low pollen-grain counts, and a site-level spatial scale. Future archaeopalynological work in the Crystal River drainage and elsewhere along the Florida Gulf Coast might improve upon our research design by: collecting sub-samples at discrete systematic intervals, improving laboratory recovery of pollen from "clean shell" strata (perhaps sampling soil trapped within gastropod shells), and by taking cores on transects throughout larger, landscape-scale, areas.

Nonetheless, our reconstruction, as contextualized within local, regional, and extra-regional paleoenvironment research, demonstrates that late-Holocene climate episodes (the RO, VM, MO, and LIA) documented throughout the North Atlantic basin are also apparent in proxy records from various locales along the Florida Gulf Coast, including the Crystal River site. Meanwhile, the comparisons drawn here suggest that late-Holocene sea-level flux likely manifested variously within different sub-regions of Florida's Gulf Coast, perhaps due to the heterogenous distribution of coastal morphodynamic conditions. This variability has important implications not only for archaeological interpretation, but also for planning and executing modern land management strategies in response to rising sea level and climate change over the coming decades (see Sassaman et al. 2014).

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