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Cultural spaces and climate change: Modeling Holocene archaeological settlement patterns on the coastal plain of the southeastern United States

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ABSTRACT

Ideal free distribution (IFD) models generally predict that populations, including human populations, will distribute themselves across the landscape such that resource access is optimized. However, links between ecology and human responses to it are not always straightforward, especially during periods of climate change when people often act based on incomplete information and for reasons not connected directly to ecological output. Here, we analyze archaeological site distribution across the coastal plains of South Carolina, Georgia, and Florida to test the roles that both ecology and knowledge of a region, as estimated based on past site occupations, played in human decision making during the Middle and Late Archaic periods. These periods correlate to substantial climatic, environmental and ecological change during the middle Holocene and beginning of the late Holocene. We find that IFD models that include both ecological variables and past landscape use fit both cultural periods, but to different degrees.

1. Introduction

As modern climate change and sea level rise intensify, understanding past human responses to climate changes becomes increasingly critical (Hauer et al., 2016; Hauer, 2017; Hauer et al., 2019). Human behavioral ecology predicts that people make accurate cost-benefit analyses concerning resources but how does one do this during periods of unstable climate and ecology (D. W. Bird and O'Connell, 2006; Codding and Jones, 2013; Codding and Bird, 2015; Bettinger et al., 1997; D. W. Bird and Bleige Bird, 1997; Jazwa et al., 2015; Jazwa et al., 2016; Kelly, 1995; Thomas, 2008, 2014; Tushingham and Bettinger, 2013; Winterhalder, 1986; Winterhalder et al., 1988; Winterhalder et al., 1999; Winterhalder and Leslie, 2002; Winterhalder et al., 2010)? To address this question, our study analyzes site distributions across two cultural periods in the southeastern (hereafter Southeast) United States: the Middle Archaic, from approximately 8900 to 5000 cal BP (6950 BCE to 3050 BCE), and the Late Archaic, from approximately 5000 to 3200 cal BP (3050 BCE to 1300 BCE)[1]. These coincide with the middle Holocene and beginning of the late Holocene, respectively, and encompass periods of transition during which coastline positions and climate conditions approached a pattern more akin to the mid 20th century (Balsillie and Donoghue, 2011; Jones et al., 2005; Joy, 2019). These changes provided both challenges and opportunities for human communities living in the region as new ecozones formed, such as rich estuaries along the coast, and others, such as the upland forests, were transformed.

There is a robust history of scholarship concerning human reactions to the Pleistocene-Holocene ecological transition in the Southeast (Anderson and Hanson, 1988; Anderson and Faught, 1998; Anderson and Gillam, 2000; Anderson, 2001; Anderson et al., 2011; Gillam, 2015; Halligan et al., 2016; Hemmings, 2004; Miller, 2016, 2018; Moore and Irwin, 2013; Schuldenrein and Anderson, 1985; Smallwood et al., 2015; Thulman, 2009). Studies of middle and late Holocene peoples in this region tend to focus on ethnogenesis and histories of practice, though climate change is not ignored (Fairbanks, 1942; Sanger, 2016, 2017; Sassaman, 1994, 2010b, 2016; Sassaman et al., 1988; A. R. Randall, 2015; Sears, 1948; Thomas, 2008, 2014). Our study adds to this body of scholarship by integrating both ecological and cultural-historical models for how people responded to climate change during the middle and late Holocene. Following a broader trend of bringing "big data" into archaeological research, particularly in the southeastern United States (Anderson, 1991a; Anderson and Horak, 1995; Anderson and Sassaman, 1996; Anderson and Gillam, 2000; Anderson, 2001; Anderson et al., 2008; Anderson et al., 2010, 2019; Wells et al., 2014; Kansa et al., 2018; Kintigh and Ammerman, 1982; Miller, 2016, 2018; Miller and Carmody, 2020; Morgan, 2008; Sassaman and Anderson,

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[1] Dates BCE calculated by subtracting 1950 from the calibrated dates derived from radiocarbon dating.

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1994; Smith and Stephenson, 2018), our study incorporates 6275 total sites from across 290,641.2 square kilometers over 5700 years. Even more broadly, this study fits within the most recent calls to address the grand challenges in archaeology of the 21st century including both past human responses to climate change, and what archaeology can suggest to us concerning what the future might hold (e.g., Anderson et al., 2017; Kintigh et al., 2014; Rick and Sandweiss, 2020). Future human reactions to destabilizing climate and shorelines may very well be predicted to some degree by past reactions.

The coastal plain province in the lower Southeast is an excellent region for testing hypotheses concerning human reactions to climate change using both ecological and cultural-historical models because past human settlement strategies appear complex and localized (Anderson and Sassaman, 2004; Anderson, Russo et al., 2007; Anderson et al., 2007; Cook Hale and Garrison, 2017, 2019; Colaninno, 2010; Thomas, 2008, 2014). For example, people occupied the Gulf of Mexico coastline densely during the Middle Archaic, but not the Atlantic coastline of Georgia, even though both coastlines share similar relative sea level curves and ecologies. Some argue that the Georgia coastal plain and coastline did not become attractive to foragers until tidal marshes developed behind the barrier islands at the opening of the Late Archaic, and that early to middle Holocene populations preferred deciduous forests inland and upland (Anderson, 1991b; DePratter, 1978; Thomas, 2008, 2014). Other studies have found no direct correlation between this gap and general ecological conditions (Cook Hale and Garrison, 2019; Turck, 2012; Williams, 1994, 2000). These studies, among others, demonstrate that while human landscape use is shaped by location and availability of critical resources, other factors are also important. These might include a lack of knowledge about resource availability, lack of access due to the presence of other groups, or a lack of mobility required to take advantage of resources.

To better model human occupation of the coastal plain during the Middle and Late Archaic, we use a model, ideal free distribution (IFD), that is drawn from human behavioral ecology (HBE) and that also implicitly includes niche construction theory (NCT). HBE assumes that human populations will choose the most advantageous environments within which to live while NCT posits that populations modify their environment to suit their needs and often then adapt and co-evolve to these modifications (Haas and Kuhn, 2019; Haas et al., 2019; Laland and O'Brien, 2010; Winterhalder et al., 2010; MacArthur and Pianka, 1966; Fretwell and Lucas, 1969). Prior studies suggest that these perspectives interdigitate well with one another and that IFD works particularly well to incorporate predictions regarding site distributions using both approaches (Stiner and Kuhn, 2016; Weitzel, 2019).

IFD models specifically assess the effects of habitat suitability on demographic distributions. They assume that populations will seek the most suitable habitat when they first enter a region. This is often, but not always framed as the one with the highest net return rates for resource extraction; non-food variables such as distance to raw materials for technological activities or other population centers often play critical roles in the IFD. Naturally, as the populations within the most ideal habitat increases, net return rates fall. Resource diminishment eventually degrades this preferred habitat until suitability within the top ranked habitat equals the suitability within a nearby second ranked habitat. At this point, IFD posits that foraging populations will move into the second ranked habitat because foraging is equally optimal in either area. IFD argues that this process will continue to iterate as populations expand. The overall effect is that suitability eventually equalizes across habitats even though final population densities differ between them (Fretwell and Lucas, 1969).

Human beings are social animals, and resource extraction is most efficient for social animals when it is a group endeavor. This characteristic adds nuance to population distributions in an IFD known as an Allée effect. As the first habitat is settled, population and niche construction activities such as intentional landscape burning (e.g. R. B. Bird and Tayor, 2013) make subsistence activities more efficient and productive. This initially increases suitability. Past a certain point, however, resource depletion occurs, and the second ranked habitat is settled, again by groups of people. This can result in temporary population depletion within the first ranked habitat as groups, not individuals, leave the top ranked habitat and settle the second ranked habitat. The Allée effect thus changes the final demographic distributions across habitats. The lowest ranked habitat may well end up with the highest population under certain conditions such as if it is the least susceptible to degradation as population rises. Along the same lines, a second-tier habitat may end up with the lowest population, depending upon the temporal point at which one measures populations during this process (Fretwell and Lucas, 1969; Robinson et al., 2019; Winterhalder et al., 2010).

One strength of IFD modeling is that it does not constrain "ideal" to ecological attributes such as biomass. Other attributes can impact habitat use. Allée effects already implicitly include niche construction, and a modified IFD model such as Ideal Despotic Distribution (IDD) that includes territorial defense may better explain final demographics where population circumscription has developed. IFD thus allows us to create a model against which we can test actual distributions. When these do not match, we can infer that populations made settlement choices based on factors not included in the original model (Fretwell and Lucas, 1969; Hakoyama, 2003; Jazwa et al., 2016; Jazwa et al., 2017; Kraft et al., 2002; Sokolowski and Tonneau, 2004; Winterhalder et al., 2010). These nuances have already been demonstrated for the Tennessee River valley from the terminal Pleistocene into the middle Holocene, at which point populations appear to have become constrained, apparently motivating these groups to initiate the first efforts at plant domestication (Miller, 2018, chap. 5).

We are also interested in the role that niche construction (NCT) may have played in human responses to the changes in climate and ecology during the later portions of the Holocene, and IFD offers a way to explore this. NCT argues that organisms are not only subject to selective pressures created by habitat constraints, but also act upon those habitats to make them more favorable. Over time, this leads to co-evolution; some examples include the development of lactose tolerance in Neolithic populations, tradeoffs between squash (spp. *cucurbita pepo*) that allowed humans to become their transport vector in exchange for improved edibility, landscape management through controlled burning, and even re-use of site locations by mobile populations spurred by the emplacement of site furniture such as hearths (Laland and O'Brien, 2010; R. B. Bird and Tayor, 2013; Banks et al., 2013; Freeman et al., 2015; Kistler et al., 2015; Stiner and Kuhn, 2016; Haas et al., 2019; Weitzel, 2019). Niche construction in response to climate change is argued for within the mid-continent and Southeast by the early Holocene (Yerkes and Koldehoff, 2018), and we are interested in what role it may have played in human responses to unstable climates during the following middle and late Holocene. Furthermore, NCT is already implied by IFD models that include Allée effects and landscape modification.

IFD explicitly assumes site re-use over time because it also assumes that highly ranked habitats remain highly ranked. However, in this study, we argue that site re-use does not necessarily correlate with suitability during periods when climate change and marine transgression changed habitat attributes such as biomass availability or distance to coastlines. We do not assume, then, that site re-use necessarily indicates continued high rank during periods of climate change. It may instead indicate risk mitigation, lack of information about newly developing ecological conditions, niche construction that buffered populations against ecological instability, or territoriality related to cultural identity. These strategies are also accounted for by IFD and IDD models but are not correlated directly to ecological attributes such as distance to coastline or net primary productivity. Instead, we argue that they are better classified as cultural responses to ecological conditions.

Because IFD is sensitive to ecological conditions along with cultural responses to them, we argue that it is particularly useful for tracking

changing landscape use during periods of climate change. These are times when resource distributions change, possibly leading to challenges such as variance between patches and/or information gaps. We hypothesize that foragers in our study area mitigated against these challenges by considering attributes that were not directly tied to their contemporary ecological conditions, such as territorial boundaries, past knowledge of local conditions, or site re-use that resulted in localized or regional niche construction.

As such, our use of IFD is not an attempt to rank habitats based upon our modern reconstructions of potential ecological resource availability and notions about how indigenous past populations *should* have made decisions. We are instead asking *how inhabitants of these landscapes themselves* defined what areas were ideal by analyzing site distributions, assumed here to be a proxy for population densities, within the context of reconstructed paleolandscapes across the study area. As such, our goal is to explore which attributes peoples themselves preferred, instead of assuming that they consciously chose directly measurable ecological conditions to best optimize net returns from a given habitat. To meet this goal, we offer an explicitly inductive statistical analysis based on a large dataset of high quality to better explore how to past human populations made decisions (Winterhalder, 2002, 208).

We apply our model to evaluate site locations using two types of attributes: those that are directly associated with ecological conditions, or those that could reflect the effects of cultural responses to contend with climate change. Strictly ecological, optimizing attributes include biomass, changes in biomass, distances to coastlines during millennia within each cultural period, distances to hydrological features, and distance to tool stone resources. We classified proximity to sites from past cultural periods, biomass from prior millennia, and distance to past coastlines, as forms of cultural responses to climate change and instability, assuming some degree of niche construction even if it is not directly detectable (Haas and Kuhn, 2019; Haas et al., 2019). Our results indicate that both ecological attributes and cultural responses to them correlated to site choice, but with different nuances depending on cultural period and sub-region.

2. The study area

The study area encompasses the coastal plains in the states of Florida, Georgia, and South Carolina, a region marked by geological, geomorphological, and hydrological variability (Fig. 1). The coastal plain of western and central Florida is characterized by carbonate bedrock and karstic geomorphology. The Floridan aquifer is unconfined in much of this region and intersects with the surface at multiple springs. The Georgia and South Carolina coastal plains, along the South Atlantic slope, differ significantly. Carbonate bedrock is replaced by increasingly thick siliciclastic formations that confine the aquifer as one moves east. Springs become less common, while rivers carry greater sediment loads. These conditions create distinctive barrier island formations along the Atlantic coastline with extensive tidal marshes between the mainland and the islands.

The climate today is humid sub-tropical across much of the study region, with mild winters and hot, humid summers; minimum temperatures rarely drop below freezing, with more rainfall in the summer months (Cfa Koppen classification). The climate warms to tropical in the southern most parts of Florida, with a notable switch to wet versus dry seasons; winters are dry but mild with temperatures rarely dropping below 10 °C, while summers are hot and humid (Aw/Am Koppen classification). These climate conditions have held since the beginning of the late Holocene, around 5000 cal BP (3050 BCE). Forest cover is mixed, ranging from oak-pine-hickory to longleaf pine, depending on humidity conditions sub-regionally. Open grassland/prairies were reported on the coastal plains of Georgia and the Carolinas as late as first contact with Europeans (Russell et al., 2009) and may be associated with intentional burning by indigenous inhabitants (Delcourt and Delcourt, 2004).

It is critical to define what we mean by "climate change" and to delineate how our study area experienced this phenomenon. For our purposes, we define climate change as shifting coastlines (greater than 2–3 m (m) per millennium), and fluctuations in the net primary productivity (NPP) of a sub-region. Relative sea level changes continued into the Late Holocene and have been documented using both archaeological survey of Late Holocene sites that are now partially submerged (DePratter, 1978; Sassaman et al., 2016; Thomas, 2008) and synthesis of multiple proxies for coastal position (Balsillie and Donoghue, 2011; Joy, 2019). Additionally, drought episodes with impacts on human populations can be detected in Florida into the Middle Holocene, though this is an area of active discussion (Balsillie and Donoghue, 2011; DePratter, 1978; Faught and Carter, 1998; Joy, 2018; A. R. Randall, 2013, 2015). We were interested in both NPP decreases caused by drought sufficient to reduce forest cover, which tends to retain higher above ground NPP (Del Grosso et al., 2008), and increases caused by ecological succession in disturbed contexts (Odum, 1960). As we will discuss further below, we used geographically sensitive z-scores, which normalize different variable measurements such that they can be meaningfully compared to one another, as a proxy for shifts in NPP. This allows us to identify how populations responded to statistically significant changes in NPP.

In brief, the middle Holocene climate of this region was warmer and more seasonal than that of the late Holocene. Arid periods are inferred from proxy data in northern Florida (Otvos, 2005; Otvos and Price, 2001), but increased rainfall and seasonal flooding was likely common further north on the coastal plain of Georgia (LaMoreaux et al., 2009; Leigh, 2008; Suther et al., 2018). Regardless of precipitation patterns, northern and central Florida experienced at least some relief from late Pleistocene to early Holocene aridity by the middle Holocene as marine transgression raised the water table (Duggins, 2012; Dunbar, 2016; Garrison et al., 2012, 2016; Halligan et al., 2016; Leigh, 2008; Russell et al., 2009; Thulman, 2009; Watts et al., 1992). After the onset of late Holocene conditions, pine increased on the Georgia coastal plain, suggesting decreased precipitation, while warm temperate forest spread further south into Florida suggesting comparative increases in rainfall (LaMoreaux et al., 2009; Watts et al., 1992).

Relative sea level (RSL) in the Southeast approached their modern positions by the end of the middle Holocene. This was not a steady state rise; sea levels at the opening of the middle Holocene were around −20 to −25 m below the modern position but rose to around −2 to −3 m below modern positions by 5000 years ago, approximately (see Joy, 2019 for detailed discussion of RSL fluctuations and rates of change along with Colquhoun and Brooks, 1986). Once marine transgression rates drop below 4–5 mm per year, it was possible for tidal marshes to form (Kirwan and Megonigal, 2013), and so periods when marine transgression dropped to, or below, this rate, these zones, with their diverse and abundant food resources, were available for human exploitation.

These ecological conditions supported a landscape rich in food resources from the coastline to the uplands. Prey species ranged from large taxa such as white-tailed deer, bear, and alligator, to smaller fauna such as rabbit and opossum. Floral resources were also abundant and included mast crops, wild fruits and vegetable taxa such as gourd (Peres, 2017). As noted above, along the coast and within river valleys, aquatic resources, including fish and shellfish, became increasingly available and bountiful as sea levels gradually stabilized (Fig. 1). Conditions conducive to oyster establishment within estuaries and marshes were present from 9000 to 8000 cal BP (7050 – –6050 BCE) and then after 7000 cal BP (5050 BCE) (Joy, 2019, Fig. 3; Kirwan and Megonigal, 2013). Coastal plain foragers thus had an abundance of subsistence resources from which to choose.

Possibly by the early Holocene, and certainly by the middle Holocene, a shift from residential to logistical mobility patterns has been posited that may reflect changing subsistence and cultural systems (Anderson and Hanson, 1988; Dunbar, 2016; Moore and Irwin, 2013).

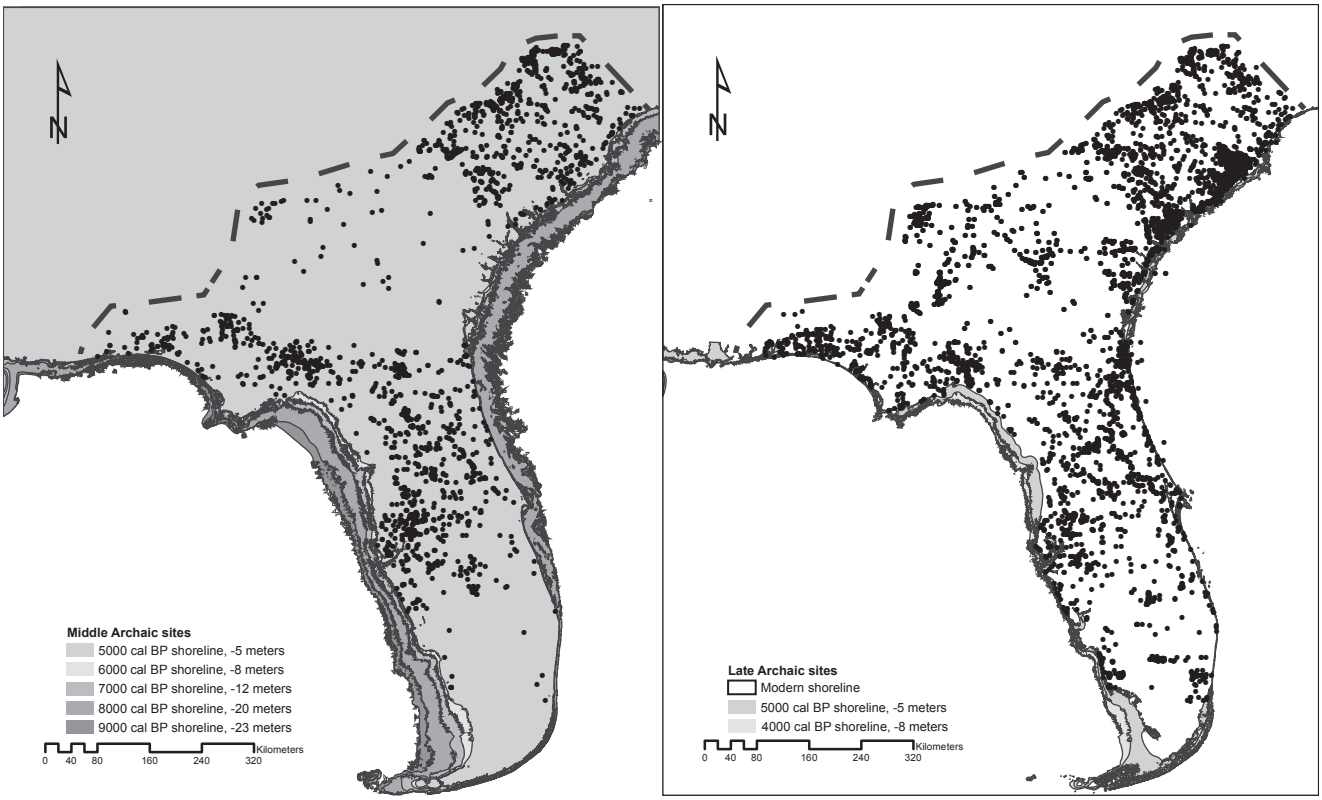

Fig. 1. Map showing distribution of Middle and Late Archaic sites on the coastal plain of Florida, Georgia, and South Carolina.

Population circumscription likely increased as well (Miller, 2018; Sassaman et al., 1988), and possibly production of goods expressly for exchange (Sassaman, 1994). Terraforming activities that suggest the first monumental architecture became visible during the latter part of the Middle Archaic and continued into the Late Archaic (A. R. Randall, 2013; A. R. Randall et al., 2014; A. Randall and Sassaman, 2017; Russo et al., 1992; Russo, 1994; Sassaman, 2005; Saunders and Russo, 2011; Thompson and Andrus, 2011; Thompson and Worth, 2011). Together, these findings strongly suggest that groups in the Southeast U.S. became larger and more diverse, with more specialized social roles and complex political engagements within and between communities. These changes resulted in the emergence of well-defined cultural groups across the Southeast (Anderson, Russo et al., 2007; Sassaman, 2016) and it is likely that these groups controlled access to their home territories as they claimed ownership over resources within them.

Middle and Late Archaic populations organized themselves and occupied the coastal plain in response to climate changes, demographic shifts, and increases in cultural complexity. However, localized patterns within the study area are inconsistent. Some areas, such as the Fall Line zone at the edge of the study area, were densely occupied during the Middle Archaic while other areas such as the lower coastal plain of Georgia lack evidence for human presence at all. Previous studies have found that baseline ecology alone cannot explain settlement patterns (Cook Hale and Garrison, 2019; Turck, 2010, 2012; Williams, 2000). This study thus sheds light on intraregional patterns that highlight complex human choices within a shifting landscape.

3. Methods

We used spatial statistical analyses in a geographic information system (GIS), ArcMap 10.7, to detect spatial patterns by examining regional site datasets. We obtained these data from Florida Master Site Files (FMSF), the Georgia Natural, Archaeological, and Historic Resources GIS (GNAHRGIS), and the South Carolina ArchSite. These data were current as of August 2019. We separated them into individual shapefiles for Middle and Late Archaic period sites, selecting only sites lying within coastal plain provinces designated as L3 ecozones following Omernik (Omernik, 1995); these are ecological regions that share similar characteristics at similar spatial scales. We examined 1968 Middle Archaic sites and 5096 Late Archaic sites.

We extracted only point locations for each site and then attached the following spatial distance attributes to each point: distances to hydrological features, coastlines at each millennium, geologic formations likely to contain desirable tool stone, and the nearest site from the preceding cultural period. Distance measurements were all calculated using the “Near” tool in ArcMap 10.7, which measures linear distance from the point location to the selected feature. We calculated distance to fluvial features or springs using data from state departments of natural resources and the United States Geological Survey (USGS) hydrological databases. We calculated shoreline positions following Joy (2019), which is the most recent relative sea level curve for the Gulf of Mexico, the Georgia Bight coastline, and the Georgia and South Carolina coastlines. We compiled data for geological formations from USGS databases by selecting formations known to contain rock types favored for tool manufacture including carbonates, chert bearing formations, metasedimentary, and metavolcanic formations (Austin et al., 2014; Sassaman et al., 1988; Upchurch et al., 1982).

We estimated net primary productivity (NPP) values by calculating temperature and precipitation averages at a millennial scale. We did this using a paleoclimate model from Bryson and DeWall (2007) that estimates temperature and precipitation for 100-year increments. This model does this by using average monthly temperature and precipitation rates drawn from NOAA climate normal data (1960–1990). This model back-calculates past temperature and precipitation for individual site locations. In our study, we used NOAA climate normal data from 1960 to 1990 for individual weather stations from Georgia, Florida, South Carolina, and North Carolina (Bryson and DeWall, 2007; Bryson, 2005). NPP is measured in grams of carbon produced per cubic meter

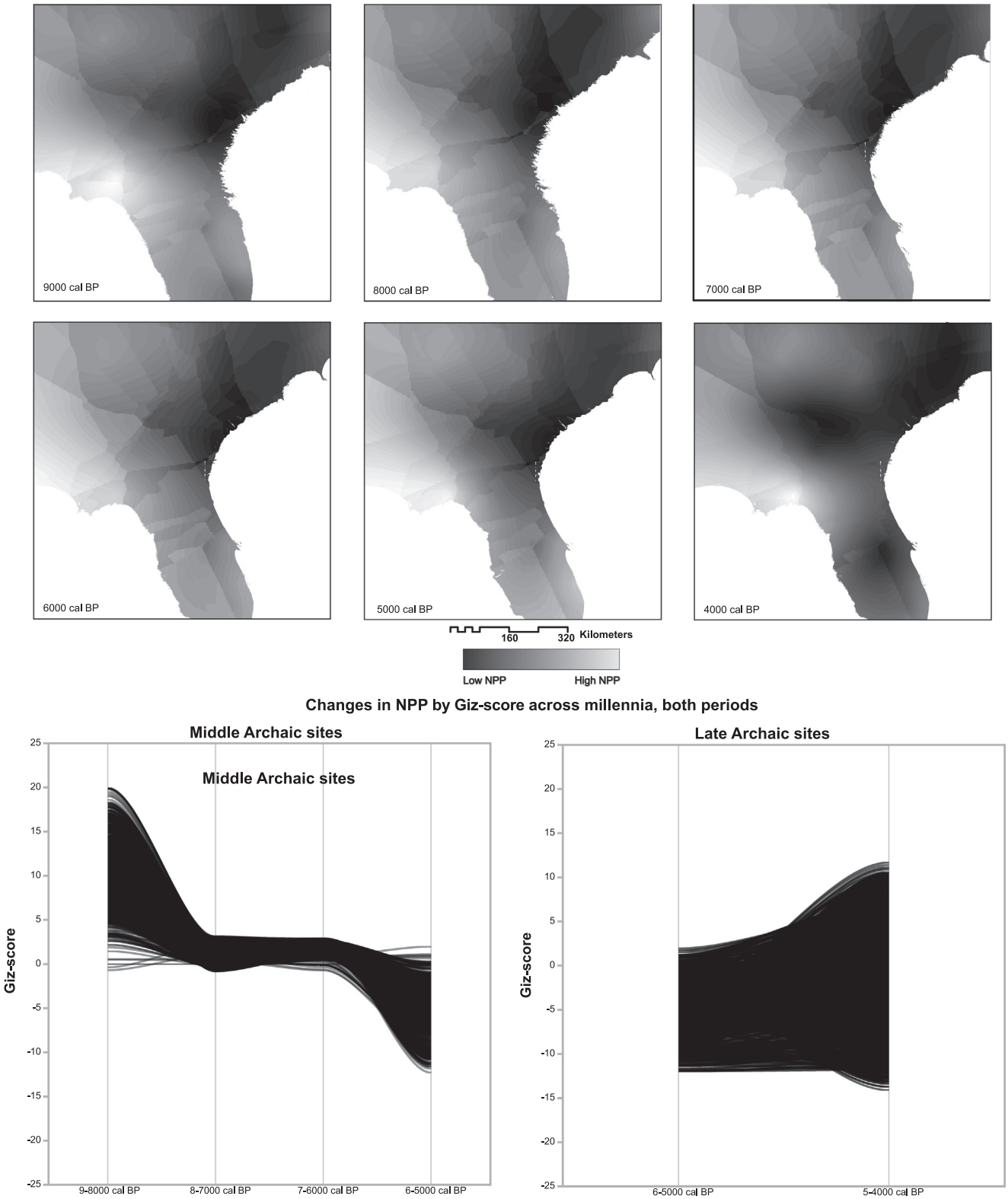

Fig. 2. NPP estimates for the study area by millennium. Graph at bottom shows variation in biomass changes through time for both cultural periods; The Middle Archaic both begins and ends with significant instability in NPP at sites occupied during this cultural period, while the Late Archaic shows varying degrees instability throughout its duration at sites occupied during this cultural period.

and drops to zero whenever temperature falls below 0 °C or rainfall drops to 0 mm. Although it does not offer insight into specific taxa available for human consumption, and has certain limitations when estimated for certain biomes (Del Grosso et al., 2008), NPP has successfully been used as a proxy for overall subsistence potential in other analyses of occupation patterns in North America (Codding and Jones, 2013; Cook Hale and Garrison, 2019). We created raster layers for every millennium from 9 KYA to 4 KYA by interpolating these point locations using Universal Kriging (Zimmerman et al., 1999). We then attached net primary productivity values to each site location using the

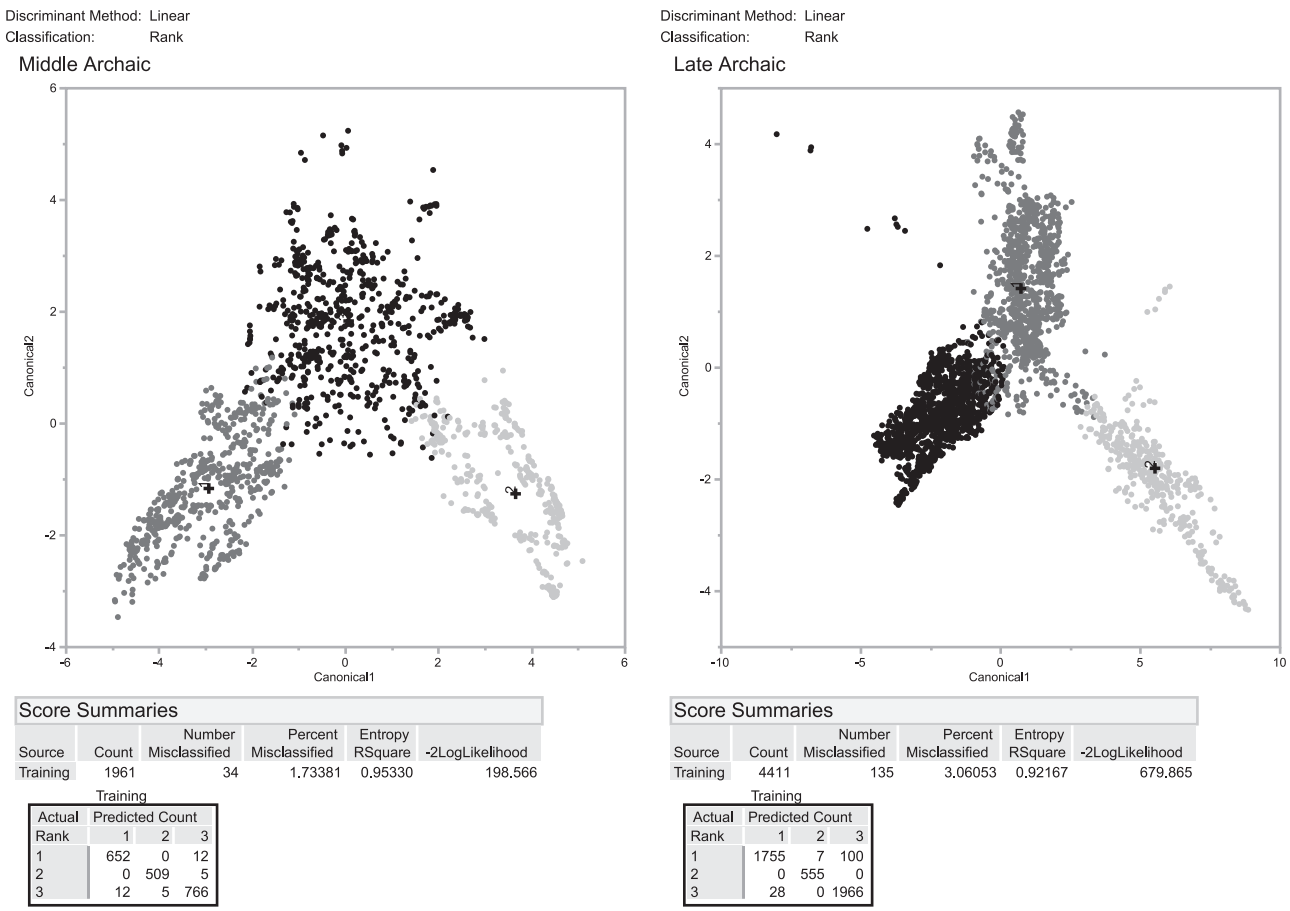

Fig. 3. Results of discriminant function analysis for clusters delineated for both cultural periods using GiZ-scores for all attributes. Both periods show low rates of misclassification, suggesting minimal potential for sites to be misidentified as belonging to the wrong cluster.

"Surface Information" tool in ArcMap 10.7. This tool reads the value of a raster cell at the point location and attaches it as an attribute to each point location in the shapefile. We also calculated change in NPP at each site by subtracting NPP during the modeled millennium from NPP during the prior millennium. This allowed us to assess changes in biomass at each site over time as a proxy for resource reliability.

We then ran optimized hot spot analysis that calculates individual Getis-Ord Gi values for each local attribute. Getis-Ord hotspot analysis tests individual points for statistically significant values correlated to variables, whether higher or lower (Ord and Getis, 1995). It assigns a geographic z-score, the GiZ-score, to each location and categorizes that point as a "hot" spot with significantly higher values, a "cold" spot with significantly lower values, or a neutral spot without significance. Optimized hotspot analysis automatically adjusts for internal data structure[2].

Following spatial statistical analyses, we imported datasets for each cultural period into JMP Pro 14. To better guard against erroneously accepting or rejecting our null hypothesis, we ran power analysis using a 2 sample *t*-test in JMP using an alpha value of 0.05 and testing each dataset using the largest standard deviation in GiZ-score for site attributes. We then ran outlier analysis. We tested each dataset for distribution then performed K means Cluster analysis assuming three clusters for each dataset. We saved cluster assignments to each data table and ran DFA analysis to test for predictive reliability. Finally, we tabulated mean values for attributes for each cluster within the datasets and compared them to expected proportions for habitat preferences in an IFD.

4. Results: How do sites relate to their surroundings?

As our review makes clear, the middle and beginning of the late Holocene were periods of environmental and social changes in the Southeast U.S., but correlations between ecological conditions, cultural factors, and population distribution have not yet been firmly established. It is possible that middle and late Holocene foragers occupied the landscape based primarily on their contemporary availability or reliability of resources, which was a moving target in areas where ecological conditions were evolving with a changing climate and shifting coastal zones. Second, foragers could instead have selected their territories based on prior knowledge of these surroundings, and/or on their own creation of favorable conditions in the form of niche construction that persisted from past. It is also possible that populations considered both contemporary resource availability and existing niches when choosing sites.

4.1. Power, distribution and cluster analysis

Power analysis indicated that 957 sites were sufficient to detect a difference of 1.645 between GiZ-scores, which accounts for 95% of the distribution assuming normal distribution following the central limit theorem (CLT). The sample sizes from both the Middle and Late Archaic period are greater than this. CLT argues that as sample sizes rise, distribution tends towards normal. As Fig. 1 shows, we do not have site data from southeastern Alabama, but power analysis results suggest that this omission is unlikely to significantly skew our final results. Our results from outlier analysis also supported removing 55 outliers in the

[2] (See https://desktop.arcgis.com/en/arcmap/latest/tools/spatial-statistics-toolbox/how-optimized-hot-spot-analysis-works.htm).

Middle Archaic dataset and 708 in the Late Archaic dataset.

Even with the removal of these outliers, in depth distribution analysis showed that the best fit for all but one attribute was a normal mixture with three clusters, for both Middle and Late Archaic datasets. The one attribute that did not fit this three clustered distribution was GiZ-scores for the NPP values at 4000 cal BP, which instead was best described by a SHASH distribution, a transformed type of normal distribution (see supplementary data for full presentation of results for all attributes for both periods)[3]. Normal mixtures result from the presence of sub-populations, each with a statistically normal distribution. To test the validity of these clusters, we re-ran power analysis assuming three groups for each cultural period. We found that our sample sizes were indeed large enough to validate the presence of these clusters. Our results showed that a sample size of 509 is sufficient to detect differences between three groups using the largest standard deviation for a GiZ-score within the dataset for the Middle Archaic period while 412 was sufficient for the Late Archaic period.

We then used K means cluster analysis using three clusters per dataset, assuming that the inclusion of one attribute from one cultural period with the SHASH distribution would not argue against this approach. JMP calculates these clusters using an iterative process. Individual sites are first assigned to temporary clusters modeled as approximations. Mean values for each attribute are then re-calculated within the clusters. Next, any sites with attributes that fall outside the new clusters are re-assigned as necessary to new clusters. The process repeats until cluster assignments stabilize[4]. The smallest Middle Archaic cluster contained 514 sites, which power analysis previously indicated was of sufficient size, while the smallest Late Archaic cluster contained 1230 sites, again indicating sufficient sample size. Our final results are thus groupings defined by site proximities to all included attributes and the final spatial distributions are based on multivariate analysis instead of a strictly geographical one.

4.2. Discriminant function analysis (DFA)

We tested clusters using Discriminant Function Analysis (DFA). DFA measures the level to which clusters overlap by returning rates of site misclassification. In DFA, clearly delineated clusters should show low rates of misclassified sites, but poorly delineated clusters will show higher rates. DFA results for both periods showed low percentages of misclassifications and high r^2 values, indicating that cluster analysis was robust. We then compared counts to demographic ratios predicted by an IFD. DFA also returns mean values for attributes that characterize each group and number of sites per cluster for each cultural period. These were used to determine if cluster proportions conform to an IFD with Allée effects (Table 1).

4.3. IFD, effective habitat suitability, and habitat quality

Our interpretations rely on the assumptions behind, and the limitations of, IFD as a population model. First, IFD models predict that populations will distribute themselves to equalize subsistence payoffs such that by the end of an IFD process, effective suitability across habitats is equal (Eq. (1)) (Greene and Stamps, 2001; Tremayne and Winterhalder, 2017; Winterhalder et al., 2010). We explicitly assume here that the site distributions we see in the archaeological record reflect an IFD (see Tables 2.Table 3.).

Eq. (1): equation giving suitability of a habitat. Si is the habitat suitability; Qi is the quality of the habitat; Bi is a scaling factor, ni is the total population (in this case, number of total sites in a cluster); Mi is the population needed to make a habitat productive. For our study, Mi is the average site cachement area for each cluster, calculated by dividing area within a cluster by the total number of sites within the cluster. From Winterhalder et al. (2010)

$$Si = Qi - Bi(ni - Mi)^2 \tag{1}$$

Our study analyzes entire cultural periods, and site distributions we see are presumably the end results of population sorting; we cannot infer the process as it was occurring because we do not have high resolution dating controls. Our data thus show what we assume are the final results of population expansion after the fact (Jazwa et al., 2015; Jazwa et al., 2016; Jazwa et al., 2017; Kennett et al., 2007; Winterhalder et al., 2010). Thus, because we are looking at time-averaged data, we predict that each cluster should have arrived at the same final effective suitability (Si).

We are, ultimately, asking how Middle and Late Archaic populations defined habitat quality, using Qi as a proxy for this. Since we are holding Si constant and know the values for ni and Mi, we can rearrange equation (1) to give Qi (Bi is adjusted to scale numerical results to an order of magnitude suitable for display; we set it at 0.0001). Rearranging Eq. (1) gives us Eq. (2).

Eq. (2): Equation giving Qi where Si is held constant, ni is number of sites within a cluster, and Mi is the average site cachement area within a cluster (rendered by dividing total area within a cluster by the number of sites within it)

$$Qi = Si + Bi(ni - Mi)^2 \tag{2}$$

Table 1 and Fig. 4 show our results. We have assigned the labels MA1, MA2, and MA3 to the Middle Archaic clusters, and the labels LA1, LA2, and LA3 to the Late Archaic clusters for clarity of discussion. We ranked these clusters by Qi score, and from this we infer effective habitat quality, or Qi. We can thus discuss cluster characteristics along with their Qi ranks.

For Middle Archaic sites, Cluster MA3 had the highest Qi score, Cluster MA1 the second highest, and Cluster MA2 the lowest. Cluster MA3 sites are defined as being located close to earlier (Early Archaic) sites, springs, stone tool resources, and the coastlines; they also have high NPP, and highly variable NPP from 8 to 6000 cal BP. MA3 sites are most commonly found in the Big Bend of Florida, where the panhandle meets the peninsula. Cluster MA1 sites were also located close to Early Archaic sites and stone tool resources, yet were far from springs and the coastlines, and had low and stable NPP. These sites are most commonly located just below the Fall Line in Georgia and South Carolina. Cluster MA2 sites were far from springs and had a GiZ-score suggesting proximity to the coastline at 8000 cal BP. These sites correlate to the coastal plain of Georgia, the peninsula of Florida along the Atlantic coast, and some of the panhandle west of the Apalachicola River delta.

For the Late Archaic sites, Cluster LA3 had the highest Qi score, Cluster LA2 the second highest, and Cluster LA1 the lowest. Cluster LA3 sites were close to Middle Archaic sites, stone tool resources, and the coastlines, but far from springs, with low but stable NPP. Cluster LA3 is primarily located in South Carolina and extends down onto the Georgia coast. Cluster LA2 was close to springs and had high but unstable NPP; this cluster correlates to the coastal plain of Georgia and the peninsula of Florida. Finally, Cluster LA1 was closer to springs, but was further upland, being particularly distant from the coastline at 7000 cal BP. It also had high but variable NPP. This cluster appears primarily distributed along the Florida panhandle and its ranking may be an artifact of sampling, since sites from Alabama were not included in this analysis.

5. Discussion

5.1. Middle Archaic site distributions

Both Cluster MA3 and Cluster MA1 showed mixed strategies in

[3] https://www.jmp.com/support/help/en/15.1/index.shtml#page/jmp/continuous-fit-distributions.shtml.

[4] See https://www.jmp.com/support/help/14–2/overview-of-the-k-means-cluster-platform.shtml for a detailed discussion.

Table 1
Tabulated results for calculations for Qi, or habitat quality. Qi is the quality of a cluster with a given set of attributes and is calculated assuming that all habitats are at suitability equilibrium. Bi is a scaling factor designed to simplify display of results; ni is the number of sites in a cluster; Mi is the number of sites in a foraging area needed to make a habitat ideally productive; we are using average site cachement area within each cluster [total area/ total sites] as a measure for this. Final rank is given based on Qi scoring.

Qi	Bi	ni	Mi	ni-Mi	Suitability	Cluster	Rank
Late Archaic							
383.02	0.0001	1994	37.75	1956.25	0.33	LA3	1
298.29	0.0001	1862	135.84	1726.16	0.33	LA2	2
24.81	0.0001	555	60.19	494.81	0.33	LA1	3
Middle Archaic							
28.59	0.0001	627	95.44	531.56	0.33	MA3	1
18.98	0.0001	512	80.17	431.83	0.33	MA1	2
17.78	0.0001	725	307.32	417.68	0.33	MA2	3

Table 2
Middle Archaic Group means by cultural period. Statistically significant GiZ-scores are bolded for higher than expected values and italicized for lower than expected values. Cluster MA2 had the highest Qi score, Cluster MA3 the second highest, and Cluster MA1 the lowest.

Middle Archaic			
Rank	**1**	**2**	**3**
Cluster	**MA2**	**MA3**	**MA1**
Attributes	**N = 725, 39%**	**N = 627, 34%**	**N = 512, 27%**
GiZ to EA	1.34	*−2.78*	*−3.52*
GiZ to springs	**1.98**	*−5.02*	**2.88**
GiZ to stone	1.67	*−3.31*	*−2.51*
GiZ 6KY coast	−1.88	*−3.77*	**11.08**
GiZ 7KY Coast	−1.9	*−3.74*	**10.98**
GiZ 8KY Coast	*−2.19*	*−2.87*	**11.38**
GiZ 9KY Coast	−1.84	*−3.11*	**10.72**
GiZ 6KY NPP	−1.13	**5.05**	**−6.13**
GiZ 7KY NPP	−1.1	**5.14**	*−6.4*
GiZ 8KY NPP	−1.11	**5.21**	*−6.63*
GiZ 9KY NPP	−1.21	**5.72**	*−6.85*
Giz NPP change by 8KY	−1.51	**7.05**	*−6.44*
Giz NPP change by 7KY	−1.08	**5.04**	*−7.71*
Giz change in NPP by 6KY	0.09	**4.69**	*−9.06*
Giz change in NPP by 5KY	**2.1**	*−2.72*	−1.02

Table 3
Late Archaic Group means by cultural period. Statistically significant GiZ-scores are bolded for higher than expected values and italicized for lower than expected values. Cluster 3 had the highest Qi score, Cluster 1 the second highest, and cluster 2 the lowest Qi score.

Late Archaic			
Rank	**1***	**2***	**3***
Cluster	**LA3**	**LA2**	**LA1**
Attributes	**Cluster 3, N = 1994, 45%**	**Cluster 2, N = 1862, 42%**	**Cluster 1, N = 555, 13%**
GiZ to Middle Archaic	*−2.94*	−0.28	−0.98
GiZ to spring	3.58	*−2.64*	*−4.01*
GiZ to stone	*−2.29*	0.28	−1.37
GiZ to 4KY/6KY coast	*−2.65*	0.12	**7.32**
GiZ to 5KY coast	*−3.6*	0.8	**6.5**
GiZ to 7KY coast	*−2.64*	**1.98**	−1.02
GiZ 4KY NPP	*−2.65*	0.12	**7.32**
GiZ 5KY NPP	*−3.6*	0.8	**6.5**
GiZ 6KY NPP	*−3.61*	1.09	**5.88**
GiZ 7KY NPP	*−3.6*	1.08	**5.99**
GiZ change in NPP by 5KY	1.38	1.96	*−7.55*
GiZ change in NPP by 4KY	*−3.65*	**2.53**	*−2.69*

coping with unstable climate. Cluster MA3 had high, and highly variable, NPP, and sites in this cluster were more likely to be coastal with a strong statistical proximity to sites from the Early Archaic. These results suggest reliance on site re-use to cope with climate change, and a willingness to adjust to shifting shorelines in return for higher biomass and access to high quality tool stone. Upland sites in Cluster MA1 sites below the Fall Line also showed preference for reoccupation of sites from the Early Archaic. These regions contained abundant high-quality tool stone and stable, if lower, NPP values. Cluster MA2 had the lowest Qi score cluster. Coastal proximity around 8000 cal BP may indicate interest in coastal resources as sea level rise slowed but no other attributes showed statistically significant patterns. Sites from this cluster extend into the coastal plain of Georgia, where settlements have been sparse since the Paleoindian period (Anderson et al., 2007; Cook Hale and Garrison, 2017, 2019; Turck, 2012; Williams, 1994, 2000). This pattern suggests that populations in this habitat only pushed into new, larger foraging ranges to mitigate risk when the more preferred habitats were not options.

Quinn and colleagues have detected evidence for individual permanent migrations into St. Johns River Valley, as well as continued visits to the Piedmont by individuals who lived primarily in this watershed, during the Middle Archaic. This watershed lies within MA2. Individuals examined by this study also showed isotopic signatures for visits to the coast, as well (Quinn et al., 2020). While this study analyzed mobility at the individual level, and ours examined population expansion at a regional level, their results appear to support ours.

Finally, Allée effects are predicted by IFD models that assume sociality plays a role in habitat suitability. Final population distributions for an IFD showing Allée effects predict that the least suitable habitat can contain the highest population once population distributions has stabilized, if it is also more resilient to the impacts of increasing population (Winterhalder et al., 2010, Fig. 2b, 272–273). An Allée effect that distributes populations in this manner, is visible in the Middle Archaic data, echoing echoes Miller's findings along the Tennessee River valley during the Middle Archaic (Miller, 2018, chap. 5; Miller and Carmody, 2020).

5.2. Late Archaic site distributions

Cluster LA3, the highest quality cluster, includes areas from the second highest quality cluster from the Middle Archaic, and the lowest quality cluster. Cluster LA2, the second highest quality cluster, overlaps even more with the lowest quality cluster from the Middle Archaic. These shifts suggest that Late Archaic populations in both clusters adjusted their strategies and assessments of high-quality habitat as the climate stabilized. Coastlines and stable NPP in Cluster LA3 were preferred even though Cluster LA1 and Cluster LA2 had higher NPP. Along a coastal zone, stable biomass typically means estuarine and marine foods such as shellfish. This should in turn have led to changes in social structures driven by foraging patterns (D. W. Bird et al., 2002; Bliege

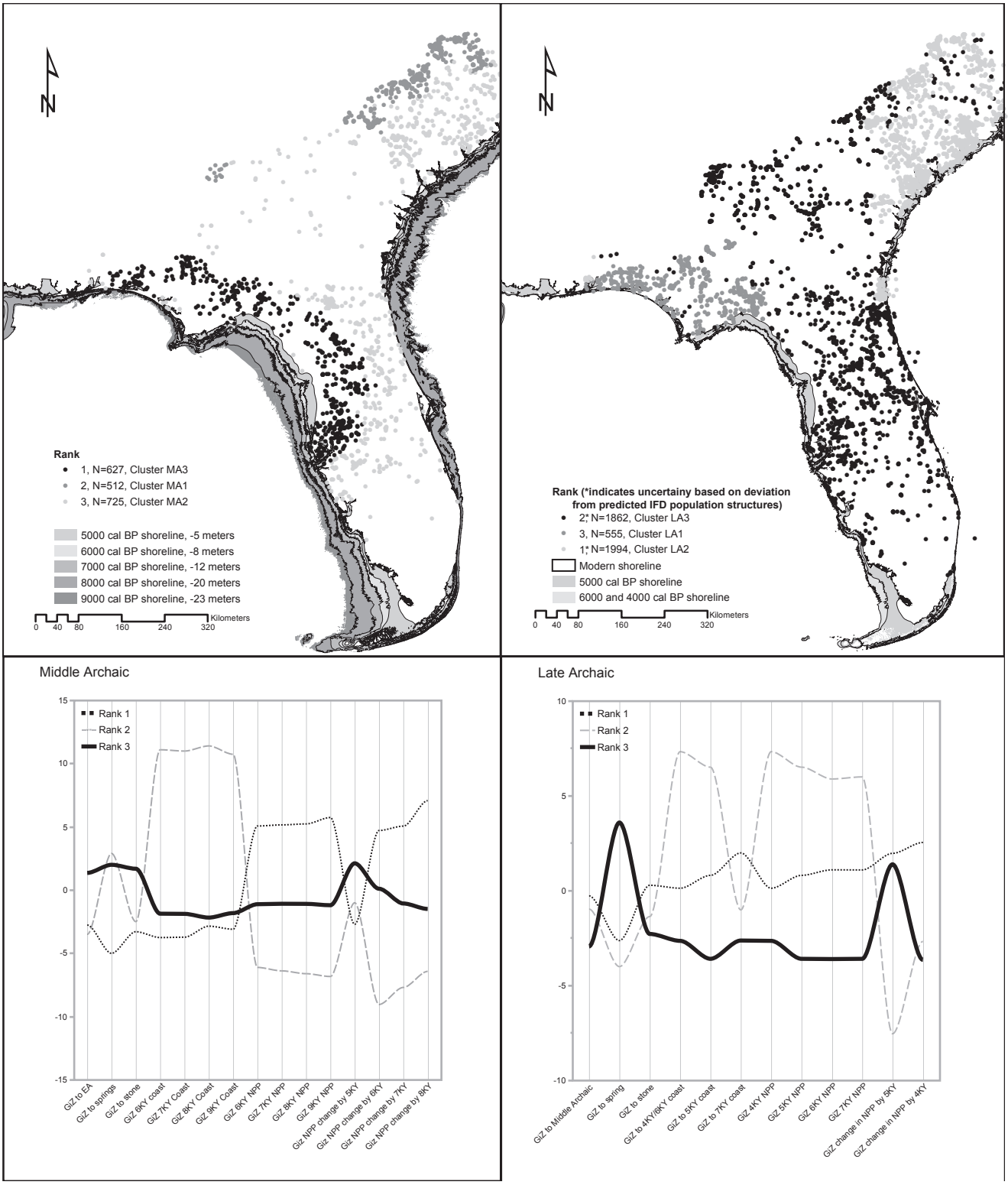

Fig. 4. Distributions for site clusters for both cultural periods. Middle Archaic distributions are consistent with IFD in terms of numbers of site per cluster, but Late Archaic distributions are not. Thus, clusters for Middle Archaic sites have been assigned ranks, while clusters for Late Archaic sites have not and are marked by an asterisk for statistical uncertainty.

Bird et al., 2009; Kelly, 1995; Thompson and Moore, 2015).

This IFD pattern also appears to have captured processes of ethnogenesis. Cluster LA3 includes areas occupied by Stallings Island culture along the Fall Line but overlaps part of the lowest quality cluster from the Middle Archaic along the lower Georgia coastal plain. Cluster LA2 has the second highest Qi score and correlates to the Orange Culture in Florida. It also includes the rest of the lowest quality Middle Archaic habitat. Technological innovations such as pottery, decreased residential mobility and the inception of village life, all appear across both areas by this time (A. R. Randall, 2013, 2015; Sassaman et al., 2006; Sassaman, 1994, 2010b, 2016). Taken together, these characteristics suggest migrations outward from ancestral areas and new

interactions between heterogenous cultural groups whose ancestors occupied habitats of varying quality (Sanger, 2016, 2017). These overlaps and changes in perceived habitat quality suggest that contact between different groups across habitats with differing suitability may have driven innovations in technologies alongside changes in cultural identity and practice. (e.g. Sanger, 2017).

While Allée effects appear in Middle Archaic distributions, they are not replicated in Late Archaic distributions. If one plots rank based Qi score against population, it is clear that the habitat with the lowest Qi score has the fewest number of sites, while the other two habitats have nearly the same numbers (see Table 1). There are multiple explanations for this. It may be that the least suitable habitat for Late Archaic settlement was also sensitive to degradation or that population sorting across different habitats was captured by our data while still ongoing. Population movements across the coastal zones of South Carolina, Georgia, and northeastern Florida are well documented at the end of the Late Archaic and into the following Woodland period (Sassaman, 2010a; Smith and Stephenson, 2018; Thompson and Turck, 2009; Turck, 2012; Williams, 2000). It may also suggest that changes in mobility patterns encouraged over or underuse of habitats by the Late Archaic or reflect the absence of sites from Alabama databases in our sample and/or the different time scales covered by each cultural period; the Late Archaic (5000 cal BP – 3500 cal BP) lasted just over half as long as the Middle Archaic (8900 cal BP – 5000 cal BP). Future study employing Ideal Despotic Distribution models (Fretwell and Lucas, 1969; Greene and Stamps, 2001; Jazwa et al., 2017) that account for limitations on movement between habitats would be a productive way to explore this finding further, along with inclusion of sites from neighboring states and later periods.

6. Conclusions

Other scholars have noted that tests of IFD are inherently tests of the underlying assumptions of the model (Winterhalder, 2002). Many of these assumptions rely on assessments of baseline ecological conditions in a study area that assume habitat quality as *a priori* conditions before testing an IFD model. We have taken a modified approach by testing for how past populations defined a habitat as "high quality" by using Qi score as a proxy such habitat quality. We have taken this approach to shed light on how populations moving into them perceived suitability. We also have included proxy attributes evidence for niche construction in the form of repeated site visits across cultural periods based on prior conditions, and not current suitability, instead. This is an inductive exercise designed to better delineate the internal data structure and is a test of predictions, not assumptions.

Middle Archaic period sites broke out into statistically meaningful clusters consistent with an IFD, and had minimal outliers (only 55, or only around 3%), suggesting statistically stable groupings. The characteristics suggest that populations prioritized both biomass availability and past occupational histories. They were also willing to exploit the somewhat riskier shifting coastlines. In the lowest quality habitat, they expanded their foraging ranges and cachement areas. We infer from this that Middle Archaic populations were risk averse, and employed a combination of information networks, occupational histories, and biomass trends when picking the most ideal habitats. In this respect, Middle Archaic site distributions are consistent with an IFD that includes both ecologically driven subsistence baselines and site re-use practices consistent with NCT.

Late Archaic period sites had far more outliers in the raw dataset (708 versus 55, or ~12% of the original datapoints), suggesting greater variation in site choices. Late Archaic groups still prioritized ancestral landscapes but included new access to the stabilizing coastlines, and stable NPP over high NPP. This is an especially important finding given that NPP variation for this period was not, in fact, generally more stable than NPP during the Middle Archaic (see Fig. 2). Further, the two clusters with the most sites are also spatially consistent with processes of ethnogenesis possibly driven by contrasting habitat suitability during the preceding Middle Archaic. Clusters LA3 and LA2 included proximity to Middle Archaic sites as well as the newly stabilizing Atlantic coastline, which offered new resources despite lower overall NPP than during the Middle Archaic. Late Archaic populations distributions appear to have been less constrained by unstable climate conditions.

Site re-use and baseline ecology influenced site distribution patterns during both cultural periods. The difference is one of nuance. Middle Archaic groups relied on both high NPP and past site locations, while Late Archaic groups expanded outward from ancestral regions and into habitats that were formerly considered lower quality, possibly assisted by technological innovations and shifts in foraging practices. This suggests that periods of climate change encouraged foragers to use a combined risk mitigation strategy including both past knowledge and present conditions. Once climate stabilized, populations were free to expand out of formerly favored habitats into areas that were previously less tenable. It is interesting that an IFD driven by unstable climate led to risk aversion, adaptability, and possible innovations in technological and subsistence practices. This is suggestive of potential implications for populations as the impacts of climate change and sea level rise are felt today (Hauer et al., 2016; Hauer, 2017; Hauer et al., 2019).

Finally, we argue that IFD, as a specific model within HBE, incorporates NCT models because it already implicitly assumes niche construction in the form of site re-use and activities designed to improve suitability while populations grow. Any perceived disconnect between HBE and NCT appears to be a false dichotomy. Our study here includes attributes such as past NPP, past distance to coastlines, and past variability in NPP, as specific proxies for site persistence even as climate change caused ecological shifts. Middle Archaic distributions were well predicted by a combination of ecological reliability and prior landscape knowledge during a period when climate and shorelines were still moving targets. Late Archaic distributions are better explained by migrations out of ancestral landscapes and into formerly less attractive zones, suggesting that populations were unpinned from earlier constraints. It appears that ideal free distributions during periods of climate change can be, at least in this region, characterized as risk averse and structured around both ecological knowledge and historical practice.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary material

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jaa.2020.101198.

References

Anderson, David G., 1991a. Examining prehistoric settlement distribution in Eastern North America. Archaeol. Eastern North Am. 19, 1–22.
Anderson, David G., 1991b. The bifurcate tradition in the South Atlantic region. J. Middle Atlantic Archaeol. 7, 23–28.
Anderson, David G., 2001. Climate and culture change in prehistoric and early historic

eastern North America. Archaeol. Eastern North Am. 29 (2001), 143–186.
Anderson, David G., Hanson, Glen T., 1988. Early archaic settlement in the Southeastern United States: A case study from the Savannah River valley. Am. Antiquity 53 (2 (Apr. 1988)), 262–86.
Anderson, David G., Horak, Virginia, (Eds.), 1995. Archaeological site file management: A southeastern perspective. In Readings in Archeological Resource Protection Series - No. 3. Atlanta, Georgia, U.S.A.
Anderson, David G., Christopher Gillam, J., 2000. Paleoindian colonization of the Americas: implications from an examination of physiography, demography, and artifact distribution. Am. Antiq. 65 (1), 43–66.
Anderson, David G., Bissett, Thaddeus G., Yerka, Stephen J., 2008. The late-pleistocene human settlement of interior North America : The role of physiography and sea-level change, 183–203.
Anderson, David G., Faught, Michael K., 1998. The distribution of fluted paleoindian projectile points: update 1998. Archaeol. Eastern North Am. 26 (1998), 163–187.
Anderson, David G., Maasch, Kirk A., Sandweiss, Daniel H., Mayewski, Paul A., 2007a. Climate and culture change: exploring holocene transitions. In: Anderson, David G., Maasch, Kirk A., Sandweiss, Daniel H. (Eds.), Climate Change and Cultural Dynamics: A Global Perspective on Mid-Holocene. Elsevier 1–24.
Anderson, David G., Russo, Michael, Sassaman, Kenneth E., 2007b. Mid-holocene cultural dynamics in Southeastern North America. In: Anderson, David G., Maasch, Kirk A., Sandweiss, Daniel H. (Eds.), Southeastern North America. In Climate Change and Cultural Dynamics: A Global Perspective on Mid-Holocene Transitions. Academic Press, Amsterdam, The Netherlands, pp. 457–490.
Anderson, David G., Sassaman, Kenneth E., 2004. Early and middle holocene periods, 9500 to 3750 B.C. In: Fogelson, Raymond D. (Ed.), Southeast Volume, Smithsonian Handbook of North American Indians. Smithsonian Institution Press, Washington, D.C..
Anderson, David G., Shane Miller, D., Yerka, Stephen J., Christopher Gillam, J., Johanson, Erik N., Anderson, Derek T., Goodyear, Albert C., Smallwood, Ashley M., 2010. 2010: Current status and findings. Archaeology of Eastern North America. Archaeology of Eastern North America 38, 63–90.
Anderson, David G., Goodyear, Albert C., Kennett, James P., West, Allen, 2011. Multiple lines of evidence for possible human population decline/settlement reorganization during the early younger dryas. Quat. Int. 242 (2), 570–583. https://doi.org/10.1016/j.quaint.2011.04.020.
Anderson, David G., Sassaman, Kenneth E., 1996. Modeling regional settlement in the archaic period southeast. In: Sassaman, Kenneth E., Anderson, David G. (Eds.), Archaeology of the Mid-Holocene Southeast. University Press of Florida, Gainesville, Florida, pp. 157–176.
Anderson, David G., Bissett, Thaddeus G., Yerka, Stephen J., Wells, Joshua J., Kansa, C., Kansa, Sarah W., Myers, Kelsey Noack, Carl Demuth, R., White, Devin A., 2017. Sea-level rise and archaeological site destruction : an example from the southeastern United States using DINAA (digital index of North American archaeology). PLoS ONE 1–25. https://doi.org/10.1371/journal.pone.0188142.
Anderson, David G., David Echeverry, D., Miller, Shane, White, Andrew A., Yerka, Stephen J., Kansa, Eric C., Kansa, Sarah Whitcher, et al., 2019. Paleoindian settlement in the Southeastern United States: The role of large databases. In: Thulman, David K., Garrison, Ervan G. (Eds.), New Directions in the Search for the First Floridians. University Press of Florida, Gainesville, Florida, pp. 241–275.
Austin, Robert J., Upchurch, Sam B., Dunbar, James S., Estabrook, Richard W., Endonino, Jon C., Burke, Adam, 2014. The quarry cluster approach to chert provenance studies, with examples from Florida. In: Southeastern Archaeological Conference. Greenville, S.C.
Balsillie, James H., Donoghue, Joseph F., 2011. Northern Gulf of Mexico sea-level history for the past 20,000 years. In: Tunnell, John W., Felder, Darryl L., Earle, Sylvia A., Buster, Noreen A., Holmes, Charles W., Camp, David K., (Eds.), Gulf of Mexico Origin, Waters, and Biota: Geology. 53–69. Harte Research Institute for Gulf of Mexico Studies Series. College Station, TX.: Texas A&M University Press. http://books.google.com/books?id=gHDQD9Q5Zb4C.
Banks, William E., Antunes, Nicolas, Rigaud, Solange, D'Errico, Francesco, 2013. Ecological constraints on the first prehistoric farmers in Europe. J. Archaeol. Sci. 40 (6), 2746–2753. https://doi.org/10.1016/j.jas.2013.02.013.
Bettinger, Robert L., Malhi, Ripan, McCarthy, Helen, 1997. Central place models of acorn and mussel processing. J. Archaeol. Sci. 24 (10), 887–899. https://doi.org/10.1006/jasc.1996.0168.
Bird, Douglas W., Bleige Bird, Rebecca L., 1997. Meriam of the torres strait Islands, Australia: Testing predictions of a central place foraging model. J. Archaeological Sci. 24, 39–63.
Bird, Douglas W., O'Connell, James F., 2006. Behavioral ecology and archaeology. J. Archaeol. Res. 14 (2), 143–188. https://doi.org/10.1007/S10814-006-9003-6.
Bird, Douglas W., Richardson, Jennifer L., Veth, Peter M., Barham, Anthony J., 2002. Explaining shellfish variability in middens on the Meriam Islands, Torres Strait, Australia. J. Archaeol. Sci. 29 (5), 457–469. https://doi.org/10.1006/jasc.2001.0734.
Bird, R.B., Tayor, N., 2013. Niche construction and dreaming logic: aboriginal patch mosaic burning and varanid lizards (Varanus Gouldii) in Australia. Proc. Royal Soc. B: Biol. Sci. 280, 20132297. https://doi.org/10.1098/rspb.2013.2297.
Bliege Bird, Rebecca, Codding, Brian F., Bird, Douglas W., 2009. What explains differences in men's and women's production?. Hum. Nat. 20 (2), 105–29. https://doi.org/10.1007/s12110-009-9061-9.
Bryson, Reid A., DeWall, Katherine McEnaney, 2007. A paleoclimatology workbook: high resolution, site-specific, macrophysical climate. Hot Springs, South Dakota, U.S.A.: The Mammoth Site of Hot Springs, S.D., Inc.
Bryson, Reid A., 2005. No title. Encylopedia of World Climatology, Encyclopedia of Earth Science Series. Springer New York.
Codding, Brian F., Bird, Douglas W., 2015. Behavioral ecology and the future of archaeological science. J. Archaeol. Sci. 56. https://doi.org/10.1016/j.jas.2015.02.027.
Codding, Brian F., Jones, T.L., 2013. Environmental productivity predicts migration, demographic, and linguistic patterns in prehistoric California. Proc. Natl. Acad. Sci. U. S. A. 110 (11), 14569–14573. https://doi.org/10.1073/pnas.1302008110.
Colaninno, Carol E., 2010. Zooarchaeological analysis of vertebrate remains from five late archaic shell rings on the Georgia coast, U.S.A. University of Georgia.
Colquhoun, Donald J., Brooks, Mark J., 1986. New evidence from the Southeastern U.S. for Eustatic components in the late holocene sea levels. Geoarchaeology 1 (3), 275–291. https://doi.org/10.1002/gea.3340010304.
Cook Hale, Jessica W., Garrison, Ervan G., 2017. Spatial statistical analysis of coastal plain paleoindian site distributions and paleoecology: implications for the search for offshore submerged sites in Georgia. Early Georgia 45 (1&2), 167–180.
Cook Hale, Jessica W., Garrison, Ervan G., 2019. Climate change, cultural adaptations, and lower coastal plain occupations of Georgia and Florida from the early to middle holocene: extrapolating spatial trends into the offshore. J. Anthropol. Archaeol. 55 (September). https://doi.org/10.1016/j.jaa.2019.101071.
Del Grosso, Stephen, Parton, William, Stohlgren, Thomas, Zheng, Daolan, Bachelet, Dominique, Prince, Stephen, Hibbard, Kathy, Olson, Richard, 2008. Global potential net primary production predicted from vegetation class, precipitation, and temperature. Ecology 89 (8), 2117–2126. https://doi.org/10.1890/07-0850.1.
Delcourt, Paul A., Delcourt, Hazel R., 2004. Prehistoric Native Americans and Ecological Change: Human Ecosystems in Eastern North America since the Pleistocene. Cambridge Studies in Adaptive Dynamics. Cambridge University Press.
DePratter, Chester, 1978. Prehistoric settlement and subsistence systems, Skidaway Island, Georgia. Early Georgia 6 (1, 2): 65–80.
Duggins, Ryan M., 2012. Florida's Paleoindian and Early Archaic: A GIS Approach to Modeling Submerged Landscapes and Site Distribution on the Continental Shelf. The Florida State University.
Dunbar, James S., 2016. Paleoindian Societies of the Coastal Southeast, first ed. University Press of Florida, Gainesville, Florida.
Fairbanks, Charles H., 1942. The taxonomic position of stalling's Island, Georgia. Am. Antiq. 7 (3), 223–231.
Faught, Michael, Carter, Brinnen, 1998. Early human occupation and environmental change in northwestern Florida. Quat. Int. 49-50, 167–176. https://doi.org/10.1016/S1040-6182(97)00061-X.
Freeman, Jacob, Peeples, Matthew A., Anderies, John M., 2015. Toward a theory of nonlinear transitions from foraging to farming. J. Anthropol. Archaeol. 40, 109–122. https://doi.org/10.1016/j.jaa.2015.07.001.
Fretwell, Stephen Dewitt, Lucas, Henry L. Jr., 1969. On territorial behavior and other factors influencing habitat development distribution in birds. Acta Biotheoretica 19 (1), 16–36.
Garrison, Ervan G., Weaver, Wendy, Littman, Shari, Cook Hale, Jessica W., Srivastava, Pradeep, 2012. Late quaternary paleoecology and heinrich events at gray's reef national marine sanctuary, South Atlantic Bight, Georgia. Southeastern Geol. 48 (4): 165–84.
Garrison, Ervan G., Cook Hale, Jessica W., Sean Cameron, Christopher, Smith, Erin, 2016. The archeology, sedimentology and paleontology of gray's reef national marine sanctuary and nearby hard bottom reefs along the mid continental shelf of the Georgia bight. J. Archaeological Sci.: Rep. 5: 240–62. https://doi.org/10.1016/j.jasrep.2015.11.009.
Gillam, J. Christopher, 2015. The early archaic cultural landscape of the coastal plain the early archaic cultural landscape of the coastal plain. South Carolina Antiquities 47 (September), 1–10.
Greene, Correigh M., Stamps, Judy A., 2001. Habitat selection at low population densities. Ecology 82 (8), 2091–2100.
Haas, Randall, Kuhn, Steven L., 2019. Forager mobility in constructed environments. Curr. Anthropol. 60 (4). https://doi.org/10.1086/704710.
Haas, Randall, Surovell, Todd A., O'Brien, Matthew J., 2019. Dukha mobility in a constructed environment: past camp use predicts future use in the Mongolian Taiga. Am. Antiq. 84 (2), 215–233. https://doi.org/10.1017/aaq.2018.88.
Hakoyama, Hiroshi, 2003. The ideal free distribution when the resource is variable. Behav. Ecol. 14 (1), 109–115. https://doi.org/10.1093/beheco/14.1.109.
Halligan, Jessi, Waters, Michael R., Perrotti, Angelina, Owens, Ivy J., Feinberg, Joshua M., Bourne, Mark D., Fenerty, Brendan, et al., 2016. Pre-Clovis occupation 14,550 years ago at the page-Ladson site, Florida, and the peopling of the Americas. Sci. Adv. 2 (5), 1–8. https://doi.org/10.1126/sciadv.1600375.
Hauer, Mathew E., Dean Hardy, R., Mishra, Deepak R., Scott Pippin, J., 2019. No landward movement: examining 80 years of population migration and shoreline change in Louisiana, pp. 369–87.
Hauer, Mathew E., Evans, Jason M., Mishra, Deepak R., 2016. Millions projected to be at risk from sea-level rise in the continental United States. Nat. Clim. Change 6 (7), 691–695. https://doi.org/10.1038/nclimate2961.
Hauer, Mathew E., 2017. Migration induced by sea-level rise could reshape the US population landscape, 7 (April). https://doi.org/10.1038/NCLIMATE3271.
Hemmings, C. Andrew, 2004. The organic clovis: a single continent-wide cultural adaptation. University of Florida. https://doi.org/10.3102/00346543067001043.
Jazwa, Christopher S., Braje, Todd J., Erlandson, Jon M., Kennett, Douglas J., 2015. Central place foraging and shellfish processing on California's Northern Channel Islands. J. Anthropol. Archaeol. 40, 33–47. https://doi.org/10.1016/j.jaa.2015.05.005.
Jazwa, Christopher S., Kennett, Douglas J., Winterhalder, Bruce, 2016. A test of ideal free distribution predictions using targeted survey and excavation on California's Northern Channel Islands. J. Archaeological Method Theory 23 (4), 1242–1284. https://doi.org/10.1007/s10816-015-9267-6.

Jazwa, Christopher S., Kennett, Douglas J., Winterhalder, Bruce, Joslin, Terry L., 2017. Territioriality and the rise of despotic social organization on Western Santa Rosa Island, California. Quat. Int. https://doi.org/10.1016/j.quaint.2017.11.009.
Jones, Douglas S., Quitmyer, Irvy R., Fred, C., Andrus, T., 2005. Oxygen isotopic evidence for greater seasonality in holocene shells of Donax Variabilis from Florida. Palaeogeogr. Palaeoclimatol. Palaeoecol. 228 (1–2), 96–108. https://doi.org/10.1016/j.palaeo.2005.03.046.
Joy, Shawn, 2018. The Trouble with the Curve: Reevaluating the Gulf of Mexico Sea-Level Curve. The Florida State University.
Joy, Shawn, 2019. The trouble with the curve: reevaluating the Gulf of Mexico sea-level curve. Quat. Int. 525 (August), 103–113. https://doi.org/10.1016/j.quaint.2019.07.023.
Kansa, Eric C., Kansa, Sarah W., Wells, Josh J., Yerka, Stephen J., Myers, Kelsey N., Demuth, Robert C., Bissett, Thaddeus G., Anderson, David G., 2018. The digital index of North American archaeology : networking government data to navigate an uncertain future for the past, 362, 490–506.
Kelly, Robert L., 1995. The Foraging Spectrum: Diversity in Hunter-Gatherer Lifeways. Percheron Press, Clinton Corners, NY http://books.google.com/books?id=RwuBAAAAMAAJ.
Kennett, Douglas J., Kennett, James P., Erlandson, Jon M., Cannariato, Kevin G., 2007. Human responses to middle holocene climate change on California's Channel Islands. Quat. Sci. Rev. 26 (3–4), 351–367. https://doi.org/10.1016/j.quascirev.2006.07.019.
Kintigh, Keith W., Altschul, Jeffrey H., Beaudry, Mary C., Drennan, Robert D., Kinzig, Ann P., Kohler, Timothy A., Fredrick Limp, W., et al., 2014. Grand challenges for archaeology. Proc. Natl. Acad. Sci. U. S. A no. May: 140–42. https://doi.org/10.1073/pnas.
Kintigh, Keith W., Ammerman, Albert J., 1982. Heuristic approaches to spatial analysis in archaeology. Soc. Am. Archaeol. 47 (1), 31–63. https://doi.org/10.2307/280052.
Kirwan, Matthew L., Patrick Megonigal, J., 2013. Tidal wetland stability in the face of human impacts and sea-level rise. Nature 504 (7478), 53–60. https://doi.org/10.1038/nature12856.
Kistler, Logan, Newsom, Lee A., Ryana, Timothy M., Clarke, Andrew C., Smith, Bruce D., Perry, George H., 2015. Gourds and squashes (Cucurbita Spp.) adapted to megafaunal extinction and ecological anachronism through domestication. PNAS 112 (49), 15107–15112. https://doi.org/10.1073/pnas.1516109112.
Kraft, John R., Baum, William M., Burge, Mark J., 2002. Group choice and individual choices: modeling human social behavior with the ideal free distribution. Behav. Process. 57 (2–3), 227–240. https://doi.org/10.1016/S0376-6357(02)00016-5.
Laland, Kevin N., O'Brien, Michael J., 2010. Niche construction theory and archaeology. J. Archaeological Method Theory 17 (4), 303–322. https://doi.org/10.1007/s10816-010-9096-6.
LaMoreaux, Heidi K., Brook, George A., Knox, John A., 2009. Late pleistocene and holocene environments of the Southeastern United States from the stratigraphy and pollen content of a peat deposit on the georgia coastal plain. Palaeogeogr. Palaeoclimatol. Palaeoecol. 280 (3–4), 300–312. https://doi.org/10.1016/j.palaeo.2009.06.017.
Leigh, David S., 2008. Late quaternary climates and river channels of the Atlantic Coastal Plain, Southeastern USA. Geomorphology 101 (1–2), 90–108. https://doi.org/10.1016/j.geomorph.2008.05.024.
MacArthur, Robert H., Pianka, Eric R., 1966. On optimal use of a patchy environment. Am. Nat. 100 (916), 603–609.
Miller, D. Shane, 2016. Modeling clovis landscape use and recovery bias in the Southeastern United States using the paleoindian database of the Americas (PIDBA) (Goebel 2004). Am. Antiq. 81. https://doi.org/10.7183/0002-7316.81.4.697.
Miller, D. Shane, 2018. From Colonization to Domestication: Population, Environment, and the Origins of Agriculture in Eastern North America. University of Utah Press, Salt Lake City, Utah.
Miller, D. Shane, Carmody, Stephen B., 2020. Fire on the mountain: the ideal free distribution and early hunter-gatherer demography in the Tennessee River Drainage, USA. Environ. Archaeol. 1–15. https://doi.org/10.1080/14614103.2020.1777054.
Moore, Christopher R., Irwin, Jeffrey D., 2013. Pine barrens and possum's rations: early archaic settlement in the North Carolina Sandhills. Southeastern Archaeology 32 (2), 169–192. https://doi.org/10.1179/sea.2013.32.2.002.
Morgan, Christopher, 2008. Reconstructing prehistoric hunter-gatherer foraging radii: a case study from California's Southern Sierra Nevada. J. Archaeol. Sci. 35 (2). https://doi.org/10.1016/j.jas.2007.02.025.
Odum, Eugene P., 1960. Organic production and turnover in old field succession. Ecology 41 (1), 34–49.
Omernik, James M., 1995. Ecoregions: A framework for managing ecosystems. The George Wright Forum 12 (1), 35–50.
Ord, J., Getis, A., 1995. Local spatial autocorrelation statistics: distribution issues and an application. Geographical Anal. 27 (4), 286–306 https://doi.org/citeulike-article-id:511265.
Otvos, Ervin G., 2005. Holocene aridity and storm phases, gulf and Atlantic Coasts, USA. Quat. Res. 63 (3), 368–373. https://doi.org/10.1016/j.yqres.2005.02.002.
Otvos, Ervin G., Price, David M., 2001. Late Quaternary Inland Dunes of Southern Louisiana and Arid Climate Phases in the Gulf Coast Region. Quat. Res. 55 (2), 150–158. https://doi.org/10.1006/qres.2001.2215.
Peres, Tanya M., 2017. Foodways archaeology: a decade of research from the Southeastern United States. J. Archaeol. Res. 25 (4), 421–460. https://doi.org/10.1007/s10814-017-9104-4.
Quinn, Rhonda L., Prizzi, Michelle, Godfrey, Linda, Setera, Jacob B., 2020. From the peidmont to the coast: LA-ICP-MS 87Sr/86Sr evidence for short-term, long-distance mobility in the American Southeast. Archaeometry. https://doi.org/10.1111/arcm.12576.
Randall, Asa R., 2013. The chronology and history of mount Taylor period (ca. 7400–4600 Cal B.P.) Shell Sites on the Middle St. Johns River, Florida. Southeastern Archaeology 32 (2), 193–217.
Randall, Asa R., 2015. Constructing Histories: Archaic Freshwater Shell Mounds and Social Landscapes of the St. Johns River, Florida. The Oxford Handbook of Culture and Psychology. University Press of Florida, Gainesville, Florida https://doi.org/10.1093/oxfordhb/9780195396430.013.0029.
Randall, Asa R., Sassaman, Kenneth E., Gilmore, Zackary I., Blessing, Meggan E., O'Donoughue, Jason M., 2014. Archaic histories beyond the shell 'heap' on the St. John's River. In: Neill J. Wallis, Asa R. Randall (Eds.), New Histories of Pre-Columbian Florida, 1st ed., 18–37. Gainesville, Florida: University Press of Florida.
Randall, Asa, Sassaman, Kenneth, 2017. Terraforming the Middle Ground in Ancient Florida. Hunter Gatherer Res. 3 (1), 9–29. https://doi.org/10.3828/hgr.2017.3.
Rick, Torben C., Sandweiss, Daniel H, 2020. Archaeology, climate, and global change in the age of humans. PNAS 117 (15), 8250–8253. https://doi.org/10.1073/pnas.2003612117.
Robinson, Erick, Jabran Zahid, H., Codding, Brian F., Haas, Randall, Kelly, Robert L., 2019. Spatiotemporal dynamics of prehistoric human population growth: radiocarbon 'dates as data' and population ecology models. J. Archaeol. Sci. 101, 63–71. https://doi.org/10.1016/j.jas.2018.11.006.
Russell, Dale A., Rich, Fredrick J., Schneider, Vincent, Lynch-Stieglitz, Jean, 2009. A warm thermal enclave in the late pleistocene of the south-eastern United States. Biol. Rev. 84 (2), 173–202. https://doi.org/10.1111/j.1469-185X.2008.00069.x.
Russo, Michael, 1994. Why we don't believe in archaic ceremonial mounds and why we should: the case from Florida. Southeastern Archaeology 13 (2), 93–109.
Russo, Michael, Purdy, Barbara A., Newsom, Lee A., Mcgee, Ray M., 1992. A reinterpretation of late archaic adaptations in central-east Florida. Southeastern Archaeology 11 (2), 95–108.
Sanger, Matthew C., 2016. Investigating pottery vessel manufacturing techniques using radiographic imaging and computed tomography: studies from the Late Archaic American Southeast. J. Archaeolog. Sci.: Rep. 9, 586–598. https://doi.org/10.1016/j.jasrep.2016.08.005.
Sanger, Matthew C., 2017. Coils, slabs, and molds: examining community affiliation between late archaic shell ring communities using radiographic imagery of pottery. Southeastern Archaeology 36 (2), 95–109. https://doi.org/10.1080/0734578X.2016.1267466.
Sassaman, Kenneth E., 1994. Production for exchange in the mid-holocene southeast: a Savannah River valley example. Lithic Technol. 19 (1), 42–51. https://doi.org/10.1080/01977261.1994.11720906.
Sassaman, Kenneth E., 2005. Poverty point as structure, event, process. J. Archaeological Method Theory 12 (4), 335–364. https://doi.org/10.1007/s10816-005-8460-4.
Sassaman, Kenneth E., 2010a. Getting from the Late Archaic to the Early Woodland in Threemiddle Valleys (Those Being the Savannah, St. Johns, and Tennessee). In: Thomas, David Hurst, Matthew, C. (Eds.), Trend, Tradition, and Turmoil: What Happened To The Southeastern Archaic? American Museum of Natural History Anthropological Papers, Sanger. New York, NY, U.S.A.
Sassaman, Kenneth E., 2010b. The Eastern Archaic, Historicized. In: Thomas, R. (Ed.), Emerson and Timothy Pauketet, first ed. AltaMira, Lanham, Maryland, Toronto, New York, Plymouth, UK.
Sassaman, Kenneth E., 2016. The multicultural genesis of stallings culture. In: King, Adam (Ed.), Archaeology in South Carolina. University of South Carolina Press, Columbia, South Carolina, U.S.A., pp. 14–33.
Sassaman, Kenneth E., Anderson, David G, 1994. Middle and Late Archaic Archaeological Records of South Carolina: A Synthesis for Research and Resource Management. Savannah River Archaeological Research Program, South Carolina Institute of Archaeology and Anthropology, University of South Carolina.
Sassaman, Kenneth E., Hanson, Glen T., Charles, Tommy, 1988. Raw material procurement and the reduction of hunter-gatherer range in the Savannah River Valley. Southeastern Archaeology 7 (2), 79–94.
Sassaman, Kenneth E., Blessing, Meggan E., Randall, Asa R., 2006. Stallings island revisited: new evidence for occupational history, community pattern, and subsistence technology. Am. Antiq. 71 (3), 539–565.
Sassaman, Kenneth E., Wallis, Neill J., Mcfadden, Paulette S., Mahar, Ginessa J., Jenkins, Jessica A., Donop, Mark C., Monés, Micah P., et al., 2016. Keeping pace with rising sea: the first 6 years of the lower suwannee archaeological survey, Gulf Coastal Florida. J. Island Coastal Archaeology, no. April. https://doi.org/10.1080/15564894.2016.1163758.
Saunders, Rebecca, Russo, Michael, 2011. Coastal Shell Middens in Florida: A view from the archaic period. Quat. Int. 239 (1–2), 38–50. https://doi.org/10.1016/j.quaint.2010.08.008.
Schuldenrein, Joseph, Anderson, David G., 1985. Prehistoric Human Ecology along the Upper Savannah River: Excavations at the Rucker's Bottom, Abbeville and Bullard Site Groups. Russell Papers: 1985. Atlanta, Ga.: The Branch, 1985. http://proxy-remote.galib.uga.edu/login?url=http://search.ebscohost.com/login.aspx?direct=true&db=cat05769a&AN=uga.9992025639029 59&site=eds-live.
Sears, William H., 1948. What is the archaic? Am. Antiq. 14 (2), 122–124.
Smallwood, Ashley M., Jennings, Thomas A., Anderson, David G., Ledbetter, Jerald, 2015. Testing for evidence of paleoindian responses to environmental changes during the younger dryas chronozone in Georgia. Southeastern Archaeology 34 (1), 23–45. https://doi.org/10.1179/2168472314Y.0000000006.
Smith, Karen Y., Stephenson, Keith, 2018. The spatial dimension of the woodland period. Southeastern Archaeology 37 (2), 112–128. https://doi.org/10.1080/0734578X.2017.1416887.
Sokolowski, M.B.C., Tonneau, F., 2004. Human group behavior: the ideal free distribution in a three-patch situation. Behav. Process. 65 (3), 269–272. https://doi.org/10.1016/j.beproc.2003.12.003.

Stiner, Mary C., Kuhn, Steven L., 2016. Are we missing the 'sweet spot' between optimality theory and niche construction theory in archaeology? J. Anthropol. Archaeol. 44, 177–184. https://doi.org/10.1016/j.jaa.2016.07.006.

Suther, Bradley E., Leigh, David S., Brook, George A., Yang, Lin Hai, 2018. Mega-meander paleochannels of the southeastern Atlantic Coastal Plain, USA (October 2017). Palaeogeogr. Palaeoclimatol. Palaeoecol. 511 52–79. https://doi.org/10.1016/j.palaeo.2018.07.002.

Thomas, David Hurst, 2008. Native American Landscapes of St. Catherines Island, Georgia. Edited by David Hurst Thomas. No. 88. New York, NY: American Museum of Natural History.

Thomas, David Hurst, 2014. The Shellfishers of St. Catherines Island: hardscrabble foragers or farming beachcombers? The J. Island and Coastal Archaeology 9 (August), 169–182. https://doi.org/10.1080/15564894.2013.840874.

Thompson, Victor D., Andrus, C. Fred T., 2011. Evaluating mobility, monumentality, and feasting at the Sapelo island shell ring complex. Am. Antiquity 76 (2 (April 2011)): 315–43.

Thompson, Victor D., Moore, Christopher R., 2015. Surplus: The Politics of Production and the Strategies of Everyday Life. In: Morehart, Christopher T., De Lucia, Kristin (Eds.), University Press of Colorado. https://doi.org/10.5876/9781607323808.

Thompson, Victor D., Turck, John A., 2009. Adaptive cycles of coastal hunter-gatherers. Am. Antiq. 74 (2), 255–278.

Thompson, Victor D., Worth, John E., 2011. Dwellers by the Sea: Native American adaptations along the southern coasts of Eastern North America. J. Archaeol. Res. 19 (1), 51–101. https://doi.org/10.1007/s10814-010-9043-9.

Thulman, David K., 2009. Freshwater availability as the constraining factor in the middle paleoindian occupation of north-central Florida. Geoarchaeology 24 (3), 243–276. https://doi.org/10.1002/gea.20268.

Tremayne, A.H., Winterhalder, Bruce, 2017. Large mammal biomass predicts the changing distribution of hunter-gatherer settlements in mid-late holocene Alaska. J. Anthropol. Archaeol. 45, 81–97.

Turck, John A., 2010. Geoarchaeological Analysis of Two Back-Barrier Islands and Their Relationship to the Changing Landscape of Coastal Georgia, U.S.A. University of Georgia.

Turck, John A., 2012. Where were all of the coastally adapted people during the middle archaic period in Georgia, USA? The J. Island Coastal Archaeology 7 (3), 404–424. https://doi.org/10.1080/15564894.2011.652763.

Tushingham, Shannon, Bettinger, Robert L., 2013. Why foragers choose acorns before salmon: storage, mobility, and risk in aboriginal California. 4. J. Anthropol. Archaeol. 32. https://doi.org/10.1016/j.jaa.2013.09.003.

Upchurch, Sam B., Strom, Richard N., Nuckels, Mark G., 1982. Methods of Provenance Determination of Florida Cherts.

Watts, W.A., Hansen, B.C.S., Grimm, E.C., 1992. Camel lake: A 40,000-Yr record of vegetational and forest history from Northwest Florida. Ecology 73 (3), 1056–1066.

Weitzel, Elic M., 2019. Declining foraging efficiency in the middle Tennessee river valley prior to initial domestication. Am. Antiq. 84 (2), 191–214. https://doi.org/10.1017/aaq.2018.86.

Wells, Joshua J., Kansa, Eric C., Kansa, Sarah W., Yerka, Stephen J., Anderson, David G., Bissett, Thaddeus G., Myers, Kelsey Noack, Carl DeMuth, R., 2014. Web-based discovery and integration of archaeological historic properties inventory data: the digital index of North American archaeology (DINAA). Literary & Linguistic Computing 29 (3): 349–60. http://10.0.4.69/llc/fqu028.

Williams, Mark, 1994. Archaeological site distributions in Georgia: 2000. Early Georgia 22 (1), 35–76.

Williams, Mark, 2000. Archaeological site distributions in Georgia: 2000. Early Georgia 28 (1), 1–55.

Winterhalder, Bruce, 1986. Diet choice, risk, and food sharing stochastic environment. J. Anthropol. Archaeol. 392 (5), 369–392.

Winterhalder, Bruce, 2002. Models. In: Hart, John P., Terrell, John Edward (Eds.), Darwin and Archaeology: A Handbook of Key Concepts. Bergin & Garvey, pp. 202–223.

Winterhalder, Bruce, Baillargeon, William, Cappelletto, Francesca, Randolph Jr. Daniel, I., Prescott, Chris, 1988. The population ecology of hunter-gatherers their prey. J. Anthropological Archaeol., 7: 289–328.

Winterhalder, Bruce, Kennett, Douglas J., Grote, Mark N., Bartruff, Jacob, 2010. Ideal free settlement of California's northern channel Islands. J. Anthropol. Archaeol. 29 (4), 469–490. https://doi.org/10.1016/j.jaa.2010.07.001.

Winterhalder, Bruce, Leslie, Paul, 2002. Risk-sensitive fertility the variance compensation hypothesis. Evol. Hum. Behav. 23, 59–82.

Winterhalder, Bruce, Lu, Flora, Tucker, Bram, 1999. Risk-sensitive adaptive tactics: models and evidence from subsistence studies in biology and anthropology. J. Archaeol. Res. 7 (4), 1–3.

Yerkes, Richard W., Koldehoff, Brad H., 2018. New tools, new human niches: the significance of the dalton adze and the origin of heavy-duty woodworking in the middle Mississippi valley of North America. J. Anthropological Archaeology 50 (November 2017): 69–84. https://doi.org/10.1016/j.jaa.2018.03.002.

Zimmerman, Dale, Pavlik, Claire, Ruggles, Amy, Armstrong, Marc P, 1999. An experimental comparison of ordinary and universal kriging and inverse distance weighting. Math. Geol. 31 (4), 375–390.