Settlement ecology in Bronze Age Messenia

Christopher S. Jazwa a,⁎, Kyle A. Jazwa b

a Department of Anthropology, The University of Nevada, Reno, 1664 N. Virginia St., MS 0096, Reno, NV 89557-0096, United States
b Department of Classics, Monmouth College, 700 East Broadway, Monmouth, IL 61462, United States

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A B S T R A C T

In this paper, we model patterns of expansion and contraction of settlement in Bronze Age Messenia (ca. 3100–1050 BCE) using the ideal free distribution (IFD). We rank potential settlement locations on the landscape using environmental and cultural variables, including watershed size, which is a proxy for fresh water availability, net primary productivity, and the distance to the location of the Palace of Nestor at Pylos, a central site of political importance throughout most of the Bronze Age. The settlement chronology for the region is derived from an existing database of survey data and conforms to the predictions of the IFD. The highest-ranked habitats were settled first and the population expanded to lower-ranked habitats as population density increased. The data also conforms to the IFD prediction that important political centers should follow the same pattern, expanding from higher- to lower-ranked habitats. This model helps to provide an understanding of the effects of the unique environmental and cultural landscape of the region on settlement prior to the rise of the major Mycenaean centers in mainland Greece. The application of the IFD to a sociopolitically complex case demonstrates its broad potential for understanding historical trajectories in settlement patterns throughout the world.

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1. Introduction

Largely because of disparate research traditions within archaeology, the Classical world has been investigated through the prism of Human Behavioral Ecology (HBE) to a lesser degree than many parts of the New World. Although HBE was initially applied primarily to mobile hunter-gatherer populations, more complex societies have increasingly become the subject of similar models in the past several decades (e.g., Smith and Winterhalder, 1992; Winterhalder and Smith, 2000; Kennett and Winterhalder, 2006; Codding and Bird, 2015). One HBE model that has received increasing attention by archaeologists has been the ideal free distribution or IFD (Åström, 1994; Fretwell and Lucas, 1969; Fretwell, 1972; Sutherland, 1983, 1996; Treganza, 1995), which is well-suited for understanding the effects of a range of environmental and socioeconomic factors on human settlement and broader patterns of decision-making and culture change (e.g., Kennett, 2005; Kennett et al., 2006, 2009; Kennett and Winterhalder, 2008; McClure et al., 2009; Winterhalder et al., 2010; Culleton, 2012; O’Connell and Allen, 2012; Jazwa et al., 2013, 2016b; Codding and Jones, 2013; Giovas and Fitzpatrick, 2014; Moritz et al., 2014; Codding and Bird, 2015; Jazwa, 2015). In this paper, we expand the reach of this model to test predictions about patterns in the expansion and contraction in the number and distribution of settlement sites in Bronze Age (ca. 3100–1050 BCE) Messenia, a region in the southwestern Peloponnese, Greece (Fig. 1).

One of the reasons that the IFD has gained traction among archaeologists and anthropologists is that it is readily scalable, both geographically and in terms of sociopolitical complexity (see Jazwa et al., 2016b). In general, the IFD uses measures of habitat suitability to generate testable predictions about population distributions and movement (Fig. 2). This can be done on large (e.g., Kennett et al., 2006; Allen and O’Connell, 2008; Fitzhugh and Kennett, 2010) and small (e.g., Culleton, 2012; Jazwa et al., 2013, 2016b) scales. The IFD has been used to understand settlement on an island-wide scale (Winterhalder et al., 2010; Jazwa et al., 2016b) and within an individual Maya polity (Culleton, 2012), but also larger scales like the initial settlement of California (Codding and Jones, 2013), the Pacific Islands (Kennett et al., 2006; Kennett and Winterhalder, 2008), and the Caribbean (Giovas and Fitzpatrick, 2014).

To establish a particular IFD model, the relative suitability of different habitats is calculated using the spatial distribution of a chosen set of environmental resources and the cultural factors which influence their value. The IFD predicts that people will first settle the habitat with the highest overall initial (prior to human

⁎ Corresponding author.
E-mail addresses: cjazwa@unr.edu (C.S. Jazwa), kjazwa@monmouthcollege.edu (KA. Jazwa).

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Influence) suitability. As people move into the habitat and population density increases, the exploitation and depletion of resources, along with interference competition, cause a decrease in the effective suitability of that habitat. Eventually, it will be advantageous for the population to expand into and settle lower ranked habitats.

A series of more specific predictions are related to these general ones (see Kennett et al., 2009; Winterhalder et al., 2010; Jazwa et al., 2013, 2016b). The ideal despotic distribution (IDD) is a variant of the IFD in which the inhabitants of a high-ranked habitat choose to defend a disproportionate share of resources. This impedes in-migration, which in turn prompts an expansion of the population to lower ranked habitats earlier than would be predicted by the IFD (Summers, 2005; Kennett and Winterhalder, 2008; Kennett et al., 2009, 2013; Culleton, 2012; Bell and Winterhalder, 2014; Jazwa, 2015; Jazwa et al., 2016b).

Messenia is a prime candidate for applying the IFD model to Bronze Age Greece because of the rich settlement data and preservation of the Bronze Age remains. The archaeological potential of Messenia remained relatively unexplored until the 1930s, partly because of peculiar historical circumstances of the region during...
antiquity. Early excavations in mainland Greece generally targeted the monumental architecture and art that is characteristic of the Classical period (ca. 480–323 BCE; McDonald and Rapp, 1972:117). The Messenians, however, did not produce similar cultural achievements at that time. Following military losses to the Spartans in the eighth and seventh centuries BC, most Messenians became subservient “helots” and disenfranchised farmers (Trytaios Frag. 3–5; Pausanias 4.3.3–4.24.6; Harrison and Spencer, 2008:148, 152–155). In this role, they were not permitted to organize in political collectives, congregate in large settlements, or acquire wealth. Thus, Messenia does not contain the Classical remains that enticed early archaeologists in Greece. The dearth of Classical material, however, is a boon to archaeologists of Greek prehistory because it helped to preserve many Bronze Age remains that might have been destroyed by later construction.

Much of what is known about settlement in Bronze Age Messenia is derived from two primary surveys, the Minnesota Messenia Expedition (MME) initiated in 1962 and the Pylos Regional Archaeological Project (PRAP) that began in 1990. MME was an extensive pedestrian survey that was the first to document settlement patterns in the region and attempt to match sites with known place names mentioned in Linear B tablets (McDonald and Rapp, 1972). Although the survey has since been criticized for its selective coverage (e.g., Simpson, 2014:9), the MME was invaluable for locating hundreds of Bronze Age sites by surface scatters of ceramics, lithics, and other artifacts. PRAP augmented the MME settlement record by conducting an intensive, systematic survey of western Messenia and the 30 km² surrounding Chora (Davis et al., 1997).

We use the existing database of archaeological sites from Messenia derived from these surveys and data from the limited number of subsequent excavations at funerary and settlement sites to test predictions of the IFD. This includes the recent Ikliana Archaeological Project (IKAP; Cosmopoulos, 2006; Simpson, 2014). This information was gleaned from Simpson’s synthesis of Bronze Age settlement in Messenia and includes sites largely within the modern boundaries of the region (Simpson, 2014). The extensive coverage of Bronze Age sites that is documented for this region provides a broader perspective to apply the IFD than in other regions with more limited survey coverage. There is also evidence of occupation of the region during the Neolithic (ca. 7000–3100 BCE). Although this occupation is generally limited in scale (McDonald and Rapp, 1972:130–131; Simpson, 2014:38), it suggests that more intensive settlement during the Bronze Age was done with some amount of environmental knowledge. This increased the likelihood that people made economically informed choices when establishing permanent settlements at the beginning of the Bronze Age.

In calculating what we believe to be the relative suitability of habitats in Messenia, we consider the role of three primary variables in our model: watershed size, which is a first-order approximation of freshwater availability; average net primary productivity, a proxy for agricultural potential; and distance to the location of the Palace at Nestor at Pylos, an especially prominent site throughout much of the Bronze Age. We demonstrate that Bronze Age settlement patterns within Messenia largely followed the predictions of the IFD, namely that there was a general expansion through time from high-ranked to lower-ranked habitats as population and the number of settlement sites in the region grew.

## 2. Bronze Age Messenia

Bronze Age chronology is largely based on ceramic typologies (Table 1). Each of the primary divisions of the Bronze Age, Early (EH; 3100–2000 BCE), Middle (MH; 2000–1600 BCE), and Late Helladic (LH; 1600–1050 BCE), is further subdivided into incrementally smaller sub-phases (e.g., Late Helladic IIIB). This relative chronology correlates to general ceramic seriations and stratigraphic data that are tied to absolute anchor dates derived from dendrochronology, the Egyptian King’s lists, and modest radiocarbon dating programs (Manning, 2010).

The Bronze Age is the earliest period of significant settlement in Messenia (McDonald and Rapp, 1972:130; Simpson, 2014:38). In the Neolithic, evidence for human activity in the region is found only at a small number of cave and open air sites (McDonald and Rapp, 1972:130–131; Simpson, 2014:38). A considerable increase in habitation occurs following the Neolithic in the EH period, especially at seaside locations. Most of these settlements are small in scale (McDonald and Rapp, 1972:132). Rescue excavations from 2007 to 2012 at Romanou, however, revealed an “extensive” Early Helladic settlement, but the precise details of the settlement are yet to be published (Bennet, 2007:37; Morgan, 2010:119–121; Rambach, 2016). Akovitika, a site near modern Kalamata, is the only site that demonstrates evidence of greater social complexity in Messenia similar to the major centers constructed elsewhere in southern and central mainland Greece. At Akovitika, two large “corridor houses” were successively constructed during the EH II period. At least one of these had a schist tile roof and a communal gathering area (Shaw, 2007). Such monumental “corridor house” structures are typically associated with more complex administration and socio-political organization in mainland Greece (Shaw, 1987; Pullen, 2008). Unfortunately, the lack of published finds from Akovitika makes it difficult to determine precisely the political and social role of this site within the region.

Like other corridor houses found in Greece, the structures at Akovitika were destroyed immediately prior to EH III (ca. 2200–2000 BCE) during a time of significant depopulation and cultural change (Rutter, 1993:773; Wiersma, 2013:165). The transition from the comparatively hierarchical EH II culture to an ostensibly egalitarian society in EH III alludes to an apparent societal crisis in much of mainland Greece. Contemporary to this are the introduction of new material forms, hybridized artifact styles, and reoriented contacts abroad (Forsén, 1992; Pullen, 2008). The precise causes of these changes still have not been determined.

In the ensuing MH period, there is a gradual increase in the number of sites in Messenia. After a short period of nearly complete depopulation in EH III, small-scale settlement slowly spreads throughout the region. The excavations at Pylos, Deriziotis Aloni, and Nichoria have revealed only glimpses of the settlements and architecture for this period (Wiersma, 2013:165). As a result, it is difficult to understand the character of settlements during the early MH period. Still, social complexity remains diminished relative to the EH II period and sociopolitical structures seem to have been minimal and relatively egalitarian.

In MH II and MH III, there is significant expansion of settlement with sites appearing in interior locations on less fertile land (Simpson, 2014:38). Familial-based social structures and status

### Table 1 Chronology for Bronze Age Greece, with general regional characteristics for each of the four time periods considered in this study.

<table>
<thead>
<tr>
<th>Chronological phase</th>
<th>Years Cal B.C.</th>
<th>Cultural characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Early Helladic</td>
<td>3100–2000</td>
<td>Early Settlement Peak</td>
</tr>
<tr>
<td>Middle Helladic</td>
<td>2000–1600</td>
<td>Regional Centers</td>
</tr>
<tr>
<td>Late Helladic I-II</td>
<td>1600–1390</td>
<td>Less Evidence for Regional Centers</td>
</tr>
<tr>
<td>Late Helladic III</td>
<td>1390–1050</td>
<td>Regional Consolidation</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Pylos Reaches its Peak</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Linear B Writing Appears</td>
</tr>
</tbody>
</table>

...
differences also become apparent with the use of multiple-burial funerary tumuli. By the end of the period, the earliest-known “tholos tomb” was constructed at Koryphasion. Tholos tombs are subterranean, corbel vaulted chamber tombs accessed by a long passage, or dromos, and covered by an earthen tumulus (Cavanagh, 2008). These structures are notable for their monumentality and substantial energy expenditure required for construction. More importantly, they are distinguished from the more modest chamber and cist tombs that predominate at cemetery sites in the region, suggesting the emergence of social stratification in the region.

There is strong evidence for continuity from the MH to LH periods in the settlement record in Messenia. Nearly all the sites that were occupied in the MH period are also inhabited in the LH period (McDonald and Rapp, 1972:136). Although Nichoria and Pylos are the only sites dating to this period that have been substantially excavated and well-published, their earliest LH phases are largely obscured by the remains from the later LH period. As a result, society in the early LH is best represented by funerary remains. Large tholos tombs appear more rapidly throughout the region with increasingly greater energy and wealth investments over time. This suggests that social stratification also increased among sites within Messenia as individuals competed for status through conspicuous consumption (Dabney and Wright, 1990:49–51). For this study, we distinguish between Late Helladic I-II (LH I-II; 1600–1390 BCE) and Late Helladic III (LH III; 1390–1050 BCE) when considering the differences in settlement between the early and later phases of the LH, following the chronological distinctions established during the MME surveys.

By LH III, a regional hierarchy of settlements is evident. In 1939, excavations on the Epano Englianos ridge near the modern town of Chora revealed a large Mycenaean complex that remains the best excavated and documented of all the “palaces” in mainland Greece (Blegen and Rawson, 1966). Archives of economic documents were also uncovered that detail the complex administrative and political structures in the region at the end of the LH (Chadwick, 1958). From the tablets, we learn that Pylos was home to a single king, or wanax, who oversaw the administration of the entire region of Messenia (Davis, 2010). Thus, it is clear that Pylos was the primary center in the region for at least the latest part of the Mycenaean period. Although Pylos achieved its greatest levels of political influence during this period, it also appears to have been an important site in Messenia earlier and throughout the Middle and Late Bronze Age (Davis et al., 1997:430).

Linear B tablets attest to the existence of several local centers that likely served as central places in attested administrative districts under the authority of Pylos (Simpson, 2014). Each district and center was required to pay taxes to the palace at regular intervals. The administrative centers appear to have had some authority over their districts. It is assumed that many of these sites were locally important prior to the advanced LH period, but were eventually taken over by Pylos and became subsidiary to the palace. Ongoing excavations at Iklaina, for instance, demonstrate that this second-order center greatly expanded in size during the middle of the LH period (Cosmopoulos, 2006). For this study, we assign any site with a size greater than 2 ha or a likely district center mentioned in the Linear B tablets a “second-order” status. We follow Simpson’s identification of known sites with the Linear B attestations (Simpson, 2014).

At the end of LH IIIB2 (ca. 1170 BCE), a crisis of some sort dramatically affected mainland Greece. All palatial centers including Pylos were destroyed in catastrophic incendiary incidents and regional political structures ceased to function as they had previously. There was also substantial depopulation throughout Greece and movement within the mainland and abroad. This LH IIIC cultural decline in Greece is without a precise explanation, but is contemporary with similar crises elsewhere in the eastern Mediterranean (Cline, 2014). Traditional narratives attribute the decline to the invasion of an outside group, such as the Dorians or the Sea Peoples, but recent studies seek more complex reasons, including climate change, internal social unrest, and/or broader disruptions to interaction in the eastern Mediterranean (Deger-Jalkotzy, 2008).

The crisis was particularly impactful in Messenia. Limited LH IIIC remains suggest a near depopulation of the entire region. Only a handful of relatively impoverished tombs that date to this period have been excavated, demonstrating the existence of a limited population (McDonald and Rapp, 1972:143; Simpson, 2014:40). An Early Iron Age settlement at Nichoria, however, indicates that the crisis was not catastrophic to long-term habitation in the region.

2.1. Bronze Age demography

There are relatively few demographic studies with which to reconstruct the population of Bronze Age Messenia. Initial estimates of 23,000 in the EBA, 118,000 in the MBA, and 178,000 in the LBA by Renfrew were made without the benefit of the latest MME data (Renfrew, 2011:249–255). More importantly, his factor of 300 persons per hectare has been argued in all subsequent studies to be overestimated. While incorporating the final MME data, McDonald and Hope Simpson (1972:128, 141) estimate a population of 50,000 in the LBA using the MME data and a lower population density factor.

This value was corroborated by Carothers and McDonald who used 1961 Greek census data to conduct a regression analysis to illuminate the relationship between settlement size and population (Carothers and McDonald, 1979). They suggested that the mean settlement size, 1.53 ha, had 140 inhabitants. When the two large centers (Pylos and Iklaina) are added separately, there is a total LBA population of 20,000 for the documented settlements (Carothers and McDonald, 1979). In the end, they reconstruct a regional population of 50,000 to account for a number of undiscovered smaller and medium sized sites (Carothers and McDonald, 1979; Simpson, 2014:42–43).

In the most recent demographic analysis, Murray (2013:142–145) suggests an overall population of 600,000 people living among (at least) 12 palatial regions of mainland Greece. Her estimate thus suggests approximately 50–70,000 people lived in Messenia, the largest region. If we accept 50,000 as an accurate value and use the population density proportions suggested by Renfrew for the earlier periods, we estimate EBA and MBA populations of 6000 and 11,000, respectively.

3. Model construction

In this study, we rank suitability of different settlement locations in Messenia based on weighted assessments of (1) watershed size, which is a first-order proxy for fresh water availability (Kennett et al., 2009; Winterhalder et al., 2010; Jazwa et al., 2016a), (2) mean net primary productivity (after Codding and Jones, 2013), and (3) distance of the drainage centroid from the Palace of Nestor at Pylos, the most prominent site during the study periods. We expect suitability to increase with proximity to Pylos because of the important administrative role of the palace and the potential for greater palatial influence on closer sites. This is similar to the variable of distance to site core used by Culleton (2012) for the settlement of the Maya center of Uxbenká, Belize.

We use watersheds as a unit of analysis for reasons similar to those given by Kennett (2005) and Kennett et al. (2009) for California’s northern Channel Islands. Fresh water availability, which is
among the most important variables in drier climates like the Mediterranean, is watershed dependent (Jazwa et al., 2016a). Furthermore, drainage size provides a convenient bin for aggregating these variables and the sites dated to each time period. Unlike the case of the modern boundary of Messenia, the modern boundary was used to select the watersheds within the study region. This is appropriate because this boundary largely corresponds to the Late Helladic administrative district of the region. We then manually merged the modeled watersheds that were part of individual drainages to create 41 total drainages used in this analysis (Fig. 1). The stream networks modeled here are in many cases ephemeral and dry for much of the year. However, most of the sites investigated in this study are alongside them, suggesting that they were capable of supporting local populations.

Watershed size was determined directly from this analysis, with the area of each modeled drainage measured in ArcGIS. Similarly, the distance from the centroid of each drainage to the Palace of Nestor in Pylos (Chora, Ano Englianos; Table 2) was also measured using this software. Net Primary Productivity (NPP) data is from the Moderate Resolution Imaging Spectroradiometer (MODIS) from NASA’s Terra satellite. MODIS data was processed following the MOD17 Photosynthesis and Net Primary Productivity algorithm made available by the Numerical Terradynamics 1 km average from 2000 to 2014 taken from the satellite data (Fig. 3: Running, 2012; see also Codding and Jones, 2013). We weight the relative contributions of each of these variables using the

Table 2
Watershed rankings for Bronze Age Messenia. z-scores are calculated for each of the primary variables and weighted by 35% drainage size, 50% average NPP, and 15% distance of the watershed centroid to the location of the Palace of Nestor.

<table>
<thead>
<tr>
<th>Rank</th>
<th>Weighted Score</th>
<th>Area</th>
<th>Average NPP</th>
<th>Distance to Pylos</th>
<th>Total number of sites</th>
<th>First/second-order sites</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>km²</td>
<td>z-score</td>
<td>kg C/m²/yr</td>
<td>z-score</td>
<td>km</td>
<td>z-score</td>
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<tr>
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<td>1.8</td>
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<td>9.0</td>
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Total
21 82 76 137 3 2 11 14
methodology in Jazwa et al. (2016b). We assign weighted z-scores for drainage area (35%), average NPP (50%), and distance of the centroid to the Palace of Nestor (15%; Table 2).

4. Model predictions

Model predictions are similar to those used in previous archaeological variants of the IFD model (see Kennett and Winterhalder, 2006; Kennett et al., 2009; Winterhalder et al., 2010; Codding and Jones, 2013; Jazwa et al., 2013, 2016b): (1) the highest ranked drainages should contain the earliest evidence for settlement sites; (2) as population expands, it should do so by establishing sites in progressively lower ranked habitats; (3) once a habitat is settled, its occupation should persist, even as population expands to progressively lower-ranked habitats. Two more predictions follow that are new to this study: (4) expansion to lower ranked areas should be coincident with an increase in the number of settlement sites within individual higher ranked habitats (i.e., decrease in suitability with increased population density); and (5) periods of regional depopulation should result in contraction to higher ranked settlement locations. Predictions 1–5 should also hold for first- and second-order population centers, which we expect to follow the same progression from high- to low-ranked habitats as settlement sites as a whole. A final prediction (6) is that technological and cultural changes that influence how people viewed the suitability variables considered in the model may cause a reorganization in settlement distribution (see Jazwa et al., 2013, 2016b).

Since dates of occupation for the settlement sites in this study are derived from ceramic chronologies rather than radiocarbon dating, it is not possible to say precisely which drainage was settled first. Rather, we test the predictions of the IFD by considering the total number of settlement sites in each of the ranked drainages for four primary time periods: Early Helladic, Middle Helladic, Late Helladic I-II, and Late Helladic III. To test the model, we assume that the number of settlement sites can be used as a proxy for population density. While this is imperfect, it provides a way to test the IFD with the available site chronology and limited demographic information.
We predict that the greatest numbers of Early Helladic sites should be disproportionately located in high-ranked drainages (prediction 1). During the Middle and Late Helladic, we should see an expansion to lower ranked drainages (prediction 2), but the settlement locations occupied during the Early Helladic should persist (prediction 3). The habitats settled early should experience an increase in the number of settlement sites as occupation expands to other habitats (prediction 4). Eventually, we expect to see expansion to the point of equilibrium suitability among all habitats, at which time further increases in population should distribute among all watersheds. During the Middle Helladic, which has been characterized as a period of depopulation (see Table 1), there may be a contraction in which watersheds were occupied (prediction 5), with lower ranked watersheds depopulated first. All of these patterns should occur for first- and second-order sites as well. Cultural change may cause a shift in settlement strategies within the IFD. Namely, a shift away from a maritime focus between the Early and Middle Helladic periods may cause a reorganization of settlement patterns, including a depopulation of coastal second-order sites (prediction 6).

5. Methods

5.1. Site database

Messenia was chosen as a study area in part because it is an area of Greece that has been the subject of significant archaeological survey coverage throughout nearly the entire region (see McDonald and Rapp, 1972; Davis et al., 1997; Simpson, 2014:9). To test the predictions of the IFD, we use the current database of all archaeological sites in Greece available as a shapefile on the website of the American School in Athens (American School, 2016). We selected those sites located within the modern boundary of Messenia and occupied in the Bronze Age using information from the MME, PRAP, IKAP, and the excavation and survey data collated in Simpson (McDonald and Rapp, 1972; Davis et al., 1997; Simpson, 2014).

Each of the 143 sites chosen in this process was assigned to a specific watershed modeled as a part of this study (SOM Table 1). In most cases, sites were located within the boundary of an individual watershed. However, in cases where the sites were not within any of the modeled boundaries, it was assigned to the watershed with the mouth closest to the site location. In all cases, these sites were located at or near the coast and there was a single nearby watershed with which it could be clearly associated.

5.2. Chronology

All of the sites included in this study were assigned to one or more of the four chronological periods used in this study. These designations were derived from the distinctions imposed by the MME project (McDonald and Rapp, 1972). Very little radiocarbon dating has been done at many of the sites considered here, so it cannot be used as a part of this study. Despite this limitation, the ubiquitous presence of ceramics provides at least some chronological designation for all of the sites in this study, a luxury that is not always available in survey data. For each of the time periods of occupation, the sites were assigned the classification of first-order settlement, second-order settlement, or other settlement site (Table 2; SOM Table 1). First-order settlements were primary political or ceremonial centers with influence over second-order settlements and beyond. Within Messenia, only the Palace of Nestor has been assigned this designation, and it was for all four chronological periods. Second-order settlements are large sites that likely had some degree of influence over other nearby settlements. Because of the limited excavation record for this region, we consider any site with over 2 ha of habitation or a likely role as the center of the Pylian administrative district a “second-order” site. Approximately 12% of the sites considered in this study are designated first- or second-order settlements at some point during the Bronze Age (Simpson, 2014). Other settlement sites at the minimum contain evidence for permanent occupation (see Winterhalder et al., 2010). It is important to note that a site that is a second-order settlement during one period may not necessarily be one during other periods. For example, a site may be a settlement site during one period and grow to a second-order site during a subsequent period.

6. Results

Overall, there is an expansion of settlement sites through time from the highest ranked drainages to progressively lower ranked ones (Figs. 4 and 5; Table 3). The highest ranked drainages are generally located in the geographic center and west of the region, tend to be large, and have a high average NPP. The top ranked area within the model is the largest drainage overall and it contains the greatest number of settlement sites throughout all time periods that were considered. The watershed including the Palace of Nestor is ranked third in the model and has the second greatest number of settlement sites for all periods. The other three drainages with the highest numbers of settlement sites through time are the second, fourth, and seventh ranked drainages. These are also relatively large and centrally located.

During the Early Helladic (Fig. 4a), settlement sites are largely confined to the drainages in the top quartile by habitat suitability (76% of EH sites). Nearly half (43%) of the total sites are located in the top ranked drainage. The large area of the drainage allows for more space for settlement sites. However, this drainage also has the most extensive ephemeral stream network, suggesting that more water was available to the inhabitants. This pattern shows that people were attracted to this habitat early in the Bronze Age. There are five sites in the drainage with the Palace of Nestor, including two prominent higher-order sites, the palace site and Romanou. Other settlement sites are relatively evenly distributed around other drainages, with one each in seven watersheds. This may suggest a centralization of political influence in one location, with other sites distributed around high-ranked areas throughout Messenia. Of the sites not within the first quartile, two – Filiatira (Stomio) and Finikous (Ayianalipsi) – are in the second quartile, but adjacent to higher ranked drainages; one, Akovitika, is in the third quartile; and one, Kalamata (Tourles) is in the lowest quartile, but not far from the top ranked drainage. Akovitika is interesting because it is a large second-order site (Shaw, 1987, 2007; Pullen, 2008). It is on the coast and near to the mouth of the top ranked drainage. Therefore, this site may be indicative of the greater maritime focus characteristic of Greece during the Early Helladic (McDonald and Rapp, 1972:131; Simpson, 2014:38).

During the Middle Helladic (Fig. 4b), there is an overall increase in total number of potential known settlement sites in Messenia from 21 to 82. Of those, 74% are located within the drainages in the highest quartile. There is some question, however, as to the designation of many of these sites as Middle Helladic. In many cases, ceramic sherds found at these sites are highly fragmentary. Therefore, it can be difficult to distinguish them from those dating to other periods in the Greek Bronze and Early Iron Ages. We have chosen to take a conservative approach and consider all sites with potential Middle Helladic dates for this study, so patterns relating to settlement during this period may be problematic. Settlement is persistent from the Early Helladic at most sites, with only 7 of 21 EH sites abandoned during the Middle Helladic. Notably, two of these are the two second-order EH sites. The depopulation of these
prominent sites may be a reflection of the social and political reorganization that occurred throughout Greece at the end of the Early Helladic (Forsén, 1992; Pullen, 2008; Wiersma, 2013:165). Further study is necessary to determine the persistence of cultural features during the crisis that occurred during EH III and the regional site hierarchy during the Middle Helladic. It is possible, however, that many of the larger Mycenaean settlements began to distinguish themselves in the middle and end of the MH period. This is supported by funerary evidence, the growing importance of tholos tombs, and evident distinctions of wealth and status. Such evidence stands in contrast to the relatively egalitarian appearance of finds within sites from earlier in the MH period. It also begins a pattern of increasing competition that sees its fullest expression in Mycenaean palatial society.

Late Helladic I-II (Fig. 4c) is the first period considered in this study with clear evidence for an increase in expansion beyond the drainages in the highest quartile (Figs. 4 and 5; Table 3). There are 76 sites that can be associated with this period, but only 50 (66%) of them are located in the highest quartile. 15 sites (20%) are in the second quartile, 8 (11%) are in the third quartile, and 3 (4%) are in the lowest quartile. Notably, all three of the sites in the lowest quartile are in the same drainage, ranked 36th in the model. This suggests that there may be something drawing people to that location that is not being considered in our IFD model. Also, 32 sites dating to the Middle Helladic were no longer occupied during the LH I-II, but this may be an artifact of the difficulty distinguishing MH ceramics from LH III ones. It is unclear whether those sites were abandoned or not yet occupied. At this time, ten

Fig. 4. Site distributions for the time periods considered in this study. Drainages are colored based on the quartile of their rank. Drainages 1–10 are in the first quartile, 11–20 the second, 21–30 the third, and 31–41 the fourth. Sites for each time period are superimposed on the site map from the preceding period. Note the relative density of sites in each ranked quartile.
second-order sites appear, suggesting an increased centralization of political influence. Nine of these are in drainages in the highest quartile of suitability, consistent with the IFD. Only Kyparissia (Kastro) is not. It is in a smaller drainage in the third quartile.

During the Late Helladic III (Fig. 4d), there is a further expansion in both total number of settlement sites and the number of sites in lower ranked drainages. There are 137 known sites dating to this period, of which 93 (68%) are in the drainages within the highest quartile. 26 sites (19%) are in drainages in the second, 12 (9%) are in the third quartile, and 6 (4%) are in the lowest quartile. Three of the sites in the lowest quartile are the same as those during LH I-II. During LH III, there is a clear expansion of settlement in drainages of all ranks within the top three quartiles. Only two sites occupied during LH I-II were not occupied during LH III, suggesting minimal site abandonment and strong continuity between these periods. There are 13 second-order sites dating to this period, including all ten that were occupied during LH I-II. Only two of these are not associated with the drainages within the highest quartile of suitability, both of which are in the 30th ranked drainage. This strong focus of politically important sites on high ranked drainages is consistent with the IFD.

7. Discussion

Overall, Bronze Age settlement within Messenia is consistent with the predictions of the IFD. The beginning of the Bronze Age represents a clear shift in settlement patterns in the region from the Neolithic. Although there were previous occupants of Messenia, there is very little evidence for Neolithic components at EH sites. Therefore, there is no reason to expect that the existing distribution of Neolithic sites created a holdover for EH site locations. The earlier occupation did provide people with the knowledge about the distribution of environmental resources within the region, allowing them to make informed choices. Therefore, the EH provides a starting point for applying the IFD.

According to the IFD, the earliest permanent settlement should occur at the highest ranked locales. During the EH, settlement in Messenia is clustered in those drainages within the top quartile based on our rankings, with a particular focus on those ranked 1 and 3 (prediction 1; Figs. 4 and 5; Table 4). Settlement within the top ranked drainage is largely driven by the size of the drainage and the relatively high amount of fresh water that would have been available to its inhabitants. The importance of fresh water is reflected in the site distribution. All of the sites in this drainage are located along one of the streams modeled as a part of this project. Although many of the streams were likely ephemeral rather than permanent, this pattern highlights the importance of fresh water availability in the region for human populations. The second primary area of focused settlement is along Messenia’s western coast and includes the drainage with the Palace of Nestor (ranked third). The high rank of this area is largely driven by the high NPP values there, which are among the highest in Messenia (Fig. 3).
proximity of these drainages to the palace also bolsters their suitability.

When considering the average NPP of a 10 km buffer around each of the Bronze Age sites considered in this study, Pylos is the highest at 10.6 (kg C)/(m² yr) (SOM Table 1). This provides a potential reason for the location of such an important site and its ability to acquire and maintain staple wealth early in the site's history. The agricultural productivity would have helped to increase the wealth at the site, allowing individuals to pool surplus resources, acquire dependent followers, and develop social hierarchies earlier than other settlements in the region (Jazwa, 2016:351–368). The excess wealth would also have been beneficial for long-distance trade that allowed higher-status individuals to distinguish themselves with conspicuous consumption of exotic and other goods. Although the ability to acquire more agricultural resources did not predetermine the success of Pylos, it certainly provided the settlement with greater potential to thrive. The importance of agriculture for Pylos is supported by theLinear B tablets which note that agricultural and animal items were used as taxes to the palace (Chadwick, 1958).

In a previous study, Galaty et al. (2014) attempt to associate settlement and trade patterns in Messenia and the Argolid with local geology and topography. Their study involves a comparison between Messenia and Argolid and focuses on LHIII primary centers, whereas ours seeks to model settlement expansion within Messenia through time and incorporates smaller settlement sites. They incorporate soil quality data from Yassoglou (2004). Although it is at a coarser scale than the MODIS NPP data and not measuring quite the same thing, Pylos appears to fall in a region of “high” soil quality (Galaty et al., 2014; Pl. CXXIXa).

There is clear evidence for an expansion of settlement through time, with more settlement sites present in Lower ranked drainages during each of the succeeding time periods (prediction 2). During the MH, there was a large jump in the number of sites from the EH. This largely occurs in the highest ranked drainages (prediction 4), but also includes an expansion to those in the second and third quartile areas in southwest and northwest Messenia. During the LH I-II, there is a similar increase in the number of settlement sites and a further expansion of settlement into those drainages within the second, third, and fourth quartiles. This pattern continues into the LH III. Population expansion as predicted by the IFD is most clearly present in the transition from the LH I-II to the LH III (predictions 2 and 4). Although the total number of sites increases from 76 to 137 between these final periods, the relative proportions of sites in drainages associated with each of the quartiles is roughly constant. By the LH I-II, all of the drainages within the highest quartile are occupied. The suitability of the higher ranked drainages had decreased because of high population densities to the levels of the lower ranked drainages. During the LH III, population expansion, and therefore further decreases in suitability, are spread out among drainages in all four quartiles. This equilibrium state, in this case watershed suitability quartiles has previously been hypothesized for archaeological contexts (see Kennett et al., 2009). The settlement patterns in Messenia show evidence of this in archaeological data, which are consistent with the fundamental conception of the IFD.

The archaeological record generally supports the prediction that occupation of individual sites should persist between periods (prediction 3). The clear exception to this prediction is the transition from the MH to LH I-II, in which 32 of the 82 sites that appear to have been occupied during the former do not have material dating to the latter. However, this is likely because of the highly fragmented nature of the ceramics from many of those sites which may lead to us assigning sites to the MH that were not occupied until later. We will continue to take a conservative approach in assigning sites to a time period until future excavations can provide materials to date them more accurately. Nonetheless, all but four sites occupied during previous time periods have deposits dating to the LH III. This is strong evidence for continuity of occupation of the sites.

In general, second-order sites follow the same overarching pattern as all settlement sites with the exception of the EH and MH. There were two second-order sites dating to the EH. One, Romanou, is located along the coast in the same drainage as Pylos, and the other, Akovitika, is located along the coast in the 25th ranked drainage, but is adjacent to the mouth of the top ranked drainage. Neither was occupied as a second-order site during any of the succeeding periods. Romanou was occupied during the LH III and a recently discovered tholos tomb suggests that the site was important locally (Bennet, 2007:37; Morgan, 2010). The diminished importance of these EH centers likely reflects the societal crisis that occurred at the end of the EH throughout mainland Greece in the Bronze Age (prediction 5). Only one of the MH sites can be identified as a second-order center at this time. During the LH I-II, sites of some importance rose to prominence, consistent with the existing archaeological and historical record for Bronze Age Greece (McDonald and Rapp, 1972:142; Bennet, 2008; Simpson, 2014:39).

The reemergence of second-order sites and their expansion during the LH III are consistent with the predictions of the IFD. They are largely present within those drainages in the highest quartile and their presence in lower ranked locations expands during the LH III. Both EH second-order sites are located along the coast, whereas only 5 of 13 LH III second-order sites are along the coast. This may be indicative of a greater maritime focus during the EH than after (prediction 6), but this interpretation is tentative.

7.1. The ideal free and ideal despotic distributions

In this study, we apply the IFD rather than the IDD to understand settlement patterns in a relatively complex system. Nonetheless, the archaeological record appears to be consistent with the predictions of the model. It is common for the IFD to be taken as a null hypothesis in population ecology models against which the effects of unequal access to resources and competition can be measured (Kennett and Winterhalder, 2006; Sutherland, 1996; Culleton, 2012). Here, the agreement between our observations and the predictions of the IFD suggests that despotic factors do not influence settlement patterns in Messenia. This differs from the expectation that cross-culturally, increasing population density and sociopolitical complexity should imply competition and the emergence of a despotic distribution (e.g., Kennett and Winterhalder, 2008). IDD distributions have been observed on California’s northern Channel Islands (Kennett et al., 2009; Jazwa et al., 2016b), the Pacific Islands (Kennett and Winterhalder, 2008), a Maya polity (Culleton, 2012), and other places.

We have three potential explanations for why the settlement distribution in Messenia differs from what has been observed elsewhere. The first is because of the unique historical trajectory of Messenia during the Bronze Age. Unlike other regions in which there were multiple competing centers, Pylos was likely the single most important site through time. The other large second-order centers were subsidiary to it, especially by the LH III. Elsewhere in Greece, competition or warfare could have led to the exclusion of people from certain regions that they otherwise may have occupied (see Kennett et al., 2006, 2009; Jazwa, 2015), but there is no evidence of this in the data presented here. Historical documents suggest that there was a political division between “hither” and “further” Messenia, which are defined as the regions on the west and east sides of Mt. Aigaleon, during the LH IIIA-B (Bennet,
2008; Simpson, 2014:29), but this does not appear to have led to despotic settlement patterns. Related to this is the fact that there is relatively high NPP throughout Messenia, particularly when compared to the rest of the Peloponnesse and Greece as a whole (Fig. 3). Therefore, there may not have been the same need to defend productive agricultural land as at other contemporary locations. Better demographic data more directly measuring population density rather than simply the number of sites would help to further test this hypothesis.

One final possibility is that in some cases, despotic behavior could result in an intensification of IFD conditions. This appears to be consistent with patterns of taxation and redistribution in Bronze Age Messenia. We know from the Linear B tablets that taxes in the form of agricultural and animal products were paid to Pylos (Chadwick, 1958). Although the Linear B tablets do not suggest a complete redistribution of resources by the palatial center, quantities of certain staple goods were received by the wanax and the palace (Halstead, 1992; Nakassis et al., 2011). When tax is paid from satellite settlements to a political center, it may benefit the elites at the center to maximize production. Halstead suggests such an “extensification” of olive oil, wheat, and wool during the end of the Mycenaean period with elites increasing the agricultural production to acquire a surplus of certain items (Halstead, 1992). This could be done by supporting a distribution consistent with the IFD, which would maintain the highest overall suitability levels. This is particularly true when population densities are sufficient to equalize suitability throughout the region, as appears to be the case during the Late Helladic. This study suggests that despotism cannot be assumed in cases of greater sociopolitical complexity.

It is quite possible as well that, when extending to a broader scale and comparing Messenia to other regions of Bronze Age Greece, settlement patterns may be more consistent with the IDD. Jazwa (2015) has speculated that it may be possible for settlement patterns matching the predictions of an IFD to be embedded within a larger system consistent with the IDD. That is, the relative population and/or site densities of larger regions (i.e., Messenia as a whole vs. other regions) may be described by the IDD, but the population and/or site densities among subregions (i.e., drainages), may follow the IFD. This could be viewed as a “nested” IFD/IDD system with the IFD system inside the IDD. A broader scale investigation of Bronze Age Greece as a whole would be necessary to test this. Nonetheless, after the Spartans took over Messenia in the 8th and 7th centuries BC, population distributions were tightly controlled (Harrison and Spencer, 2008:155–157). At that time, settlement in Messenia would have been more appropriately described by the IDD.

7.2. Limitations and future directions

This is a relatively coarse-grained application of the IFD to understanding settlement patterns in Bronze Age Messenia. The primary limitation to the study is the difficulty of distinguishing highly fragmented and degraded ceramic sherd in some cases. However, the fact that ceramic dates are available for all of the sites included in this study is also one of its greatest strengths because it allows a wide variety of sites recorded on survey to be included. Excavation of a greater subset of the sites from habitats of a range of relative suitability levels would refine their chronologies and provide valuable information about temporal changes in settlement size and resource depression (Jazwa et al., 2016b). Similarly, continued research and publication of the finds at the EH centers of Romanou and Akovitika can provide further information about whether there was a greater maritime focus that may have influenced how people distributed themselves on the landscape.

An interesting apparent exception to the predictions of the IFD is the focused occupation of the drainage ranked 38th in this model, located in southeast Messenia and northern Mani (Figs. 1 and 4). It is reasonable to have individual locations in low-ranked drainages that are settled early, particularly at low population densities (see Jazwa et al., 2016b). This can often occur because there are enough resources to sustain a small population, while population expands more rapidly in high-ranked habitats. However, the fact that three are within the same drainage once more settlement sites are established in low-ranked southeast Messenia suggests that there may be valuable resources in that location that we do not consider here. Alternatively, the long habitation of the caves in the region in the Neolithic period may have also facilitated settlement using a familiarity of the region and its resources by the local population (Papathanassopoulos, 1971; Papanasiasiou, 2005, 2009). The fact that there are no known palatial centers or significant Mycenaean settlements in Mani suggests that its settlement was likely not influenced by a distinct political entity from the rest of Messenia.

Bronze Age Messenia also provides an opportunity to develop applications of the IFD and IDD. We predicted (prediction 5) that there should be a contraction in settlement between the Early and Middle Helladic based on patterns observed elsewhere in Bronze Age Greece. While past applications of the IFD and IDD have focused primarily on settlement expansion through time, comparatively little attention has been paid to what happens during times of decreasing population density. With more work to refine site chronologies, Bronze Age Messenia can be used as a case to better address this phenomenon. Furthermore, because settlement in this region is distributed throughout the drainages considered in the study, rather than isolated on the coast like in the example from California (e.g., Winterhalder et al., 2010; Jazwa et al., 2016b), Messenia can be used to understand better a “nested” approach to the IFD/IDD. A radiocarbon dating program that adds more detail to the occupation chronology would likely reveal information about patterns of occupation within each drainage.

8. Conclusions

Analysis of a database of known Bronze Age archaeological sites in Messenia supports the predictions of the IFD (Table 4). In general, those watersheds ranked highest in the model experienced the most intensive settlement during the EH based on ceramic chronologies. As population density (i.e., number of sites) increased during the MH and LH, settlements expanded into progressively lower ranked drainages, with a large amount of continuity of settlement between the periods. The same pattern occurred among second-order centers, with an expansion from high-ranked drainages into lower ranked ones during the LH. It is in these centers that the effects of the collapse on social complexity that occurred at the end of the EH are evident, with none of those occupied previously having evidence for occupation during the MH. Despite the relatively high levels of political complexity within Bronze Age Greece, we show that settlement in Messenia is more consistent with the IFD than the IDD, likely because of the unique historical trajectory of the region, namely the political primacy of Pylos. It may represent a case of an IFD distribution “directed” from the political center.

This study represents an expansion in the application of the IFD and IDD models to the Mediterranean and demonstrates the broadening applicability of this kind of model for understanding human settlement patterns. We investigate these patterns at an intermediate scale to provide a starting point for understanding the relationship between population expansion in Greece during the Bronze Age. We incorporate variables from models targeted at a smaller scale (drainage size; see Kennett et al., 2008; Jazwa et al., 2016b), a larger scale (NPP; see Codding and Jones, 2013), and
one derived from the unique sociopolitical circumstances of the region (distance to the Palace of Nestor). An important benefit of models such as these is the flexibility to include a broad range of environmental, economic, and cultural variables in this way. Here, we confirm the predictions of the IFD for Messenia using chronological data from past surveys. In doing so, we demonstrate the applicability of this model to a more sociopolitically complex case than it has been used for previously and its potential for understanding other cases elsewhere in the world.

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Appendix A. Supplementary material

Supplementary data associated with this article can be found, in the online version, at http://dx.doi.org/10.1016/j.jaa.2016.12.003.

References


