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Late Chalcolithic to Late Bronze Age Settlement Patterns in the Gorgan Plain (ca. 3200-1600 BCE)

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Abstract

The Gorgan Plain in Golestan Province is one of the most archaeologically rich regions in Iran. Given its favorable climate, the Gorgan Plain has been an attractive location for settlement by agricultural villagers for millennia. In the 19th and 20th centuries, the region attracted the attention of European travelers and archaeologists, who were fascinated by the Great Gorgan Wall, the remains of medieval cities, as well as the hundreds of ancient mounds that dot the plain. Despite over one hundred years of archaeological survey in the Gorgan Plain, however, we still know very little about historical trends in settlement before the Iron Age. Through the digital integration of five previously published surveys of the Gorgan Plain and a novel remote survey methodology using Google Earth, it has been possible for the first time to perform a basic characterization of the late prehistoric settlement patterns of the Gorgan Plain.

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1. Introduction

The archaeological landscape of the Gorgan Plain has been surveyed on multiple occasions, resulting in the accumulation of a large dataset comprising the locations, dimensions, toponymy, and cultural aspects of hundreds of ancient settlements in the region (Abbasi 2011; Arne 1945; Kayani 1974; Mortezaei and Farhani 2008; Sauer *et al.,* 2013; Shiomi 1976, 1978). However, because these surveys were conducted over disparate decades by scholars with distinct disciplinary and national backgrounds, synthesis of these data has proven elusive until recently. Despite differences in methods and approach between these surveys, the data presented in their reports are structured in similar ways. These similarities afford relatively easy integration of their results into a unified regional database. This article presents the procedure by which these surveys were characterized, compared, and augmented through a remote virtual survey protocol. This methodology focused on three major objectives: (1) examining the extent to which the information presented in the published surveys was comparable and (2) assessing the accuracy of the published surveys, and (3) "visiting" each reported site location in Google Earth to verify whether there was indeed a mound-settlement in that location and to record its characteristics through visual inspection of satellite imagery. This information was registered in a Microsoft Access database, which also encoded chronological information reported by the legacy surveys. This reported chronological data was supplemented by a review of published photographs and illustrations of pottery, as well as examination of a collection of survey ceramics from the Gorgan Plain stored in Sweden in order to validate and update the region's site chronology.

This procedure led to two primary results. First, the recognition that the spatial data presented in these legacy surveys is generally reliable, despite variations in coordinate systems and methods of recording site attributes, and second, the identification of a large sample of previously unidentified, likely prehistoric, mounded settlements. Furthermore, the creation of a digital site database for the Gorgan Plain made it possible to perform Exploratory Data Analysis on the historical development of settlement patterns in this region. This analysis charts change over time in settlement distributions, focusing on variation in site location, numbers of sites, and site-size from the Late Chalcolithic to the Late Bronze Age (ca. 3200-1600 BCE). The results of this procedure show that the Gorgan Plain exhibits a unique trajectory of transformations in its settlement geography in comparison to the neighboring areas such as the Caspian Littoral, the North Central Iranian Plateau, Khorasan, and southern Central Asia.

2. Examination and augmentation of previous surveys of the Gorgan Plain

The historical landscape of the Gorgan Plain has long fascinated European travelers, with reports on and accounts of the location and characteristics of archaeological, geological, and hydrological features of the region appearing as early as the mid-19th century (e.g., Arne 1935; De Bode 1844; De Morgan 1890; Hedin 1918; Rabino 1928; Thompson 1938). While these early reports identified dozens of archaeological sites, systematic archaeological site prospection was not initiated until 1933 when T.J. Arne and W. Schweitzer created the first cartographic archaeological map of the region (Arne 1945: 12-22). Archaeological survey of the Gorgan Plain has continued intermittently ever since, conducted by both foreign and Iranian researchers. One of the main aims ongoing research by the present author has been to integrate, synthesize, and extend the results of

these regional surveys of the Gorgan Plain conducted between 1931 and 2009. Such work faces many challenges, resulting from the heterogeneity of source-data collected during disparate decades, under diverse disciplinary paradigms, and using differing recording methods (Alcock and Cherry 2004; Allison 2008; Witcher 2008).

These obstacles are insurmountable, however. Indeed, over the past decade, archaeologists have developed a number of ways to harmonize the morphological, chronological, and locational information contained within legacy data sources (Lawrence *et al.,* 2012). Here the procedures and results of source criticism conducted on the surveys of the Gorgan Plain are discussed. This procedure begins by characterizing the reported data followed by comparison of the sources based on their survey design, methods geographic representation, and modes of site description. The published and unpublished records from four of these surveys and one site gazetteer constitute the primary sources of legacy survey data used in this analysis (Abbasi 2011; Arne 1945; Mortezaei and Farhani 2008; Sauer *et al.,* 2013; Shiomi 1976, 1978). These sources offer comprehensive coverage of the parts of Golestan province that are most dense in archaeological sites, i.e., the zone south of the Gorgan Plain river and north of the Alborz mountains (Fig. 1).

According to the three categories of evaluation criteria—survey design, geographic representation, and site description—the surveys exhibit less diversity in their structure than might otherwise be expected, especially given the eighty years separating the earliest from the most recent surveys, as well as the range of disciplinary and national backgrounds of the researchers involved. This similarity can be explained by the nature of the settlement record in the region, for two related reasons: (1) the Gorgan Plain is a landscape of tells and (2) in general, low-intensity large-scale approaches to mapping landscapes of tells tend to record similar categories of information. The basic variables recorded by previous surveys include location, toponymy, morphology, and surface finds; additional variables may or may not include taphonomy, textual descriptions, and graphic representations (Table 1).

3. Using Google Earth to evaluate reported site locations

In recent years, scholars have begun to extend the domain of comparative survey by augmenting existing records through systematic remote site prospection (e.g., Franklin and Hammer 2018; Green and Petrie 2018; Hammer *et al.,* 2018; Hammer and Lauricella 2017; Thomas and Kidd 2017). Thus, in addition to the descriptive source criticism detailed in the previous section, this analysis also involved a virtual remote survey (Gorgan Plain Survey Restudy, hereafter GSR) in order to re-locate and re-record previously reported site locations and to systematically examine Google Earth satellite imagery for previously unreported tell-settlements in the region. Altogether, over 1200 unique sites were extracted from the five sources (Table 2, Fig. 2). For the purpose of this analysis, not all sites were "visited," with the sample restricted to only those sites dating to the period of focus, i.e., the Late Chalcolithic through Late Bronze Age. There were 851 sites in the database dating to this interval, all of which were checked in Google Earth. As a result of this procedure, a sample of 663 unique sites was confirmed, with the gap between the reported and recorded sites being due to two factors: (1) a large number of sites reported in multiple surveys turned out to in fact be the same site and (2) numerous sites could not be located for a variety of reasons (Table 2; Fig. 3).

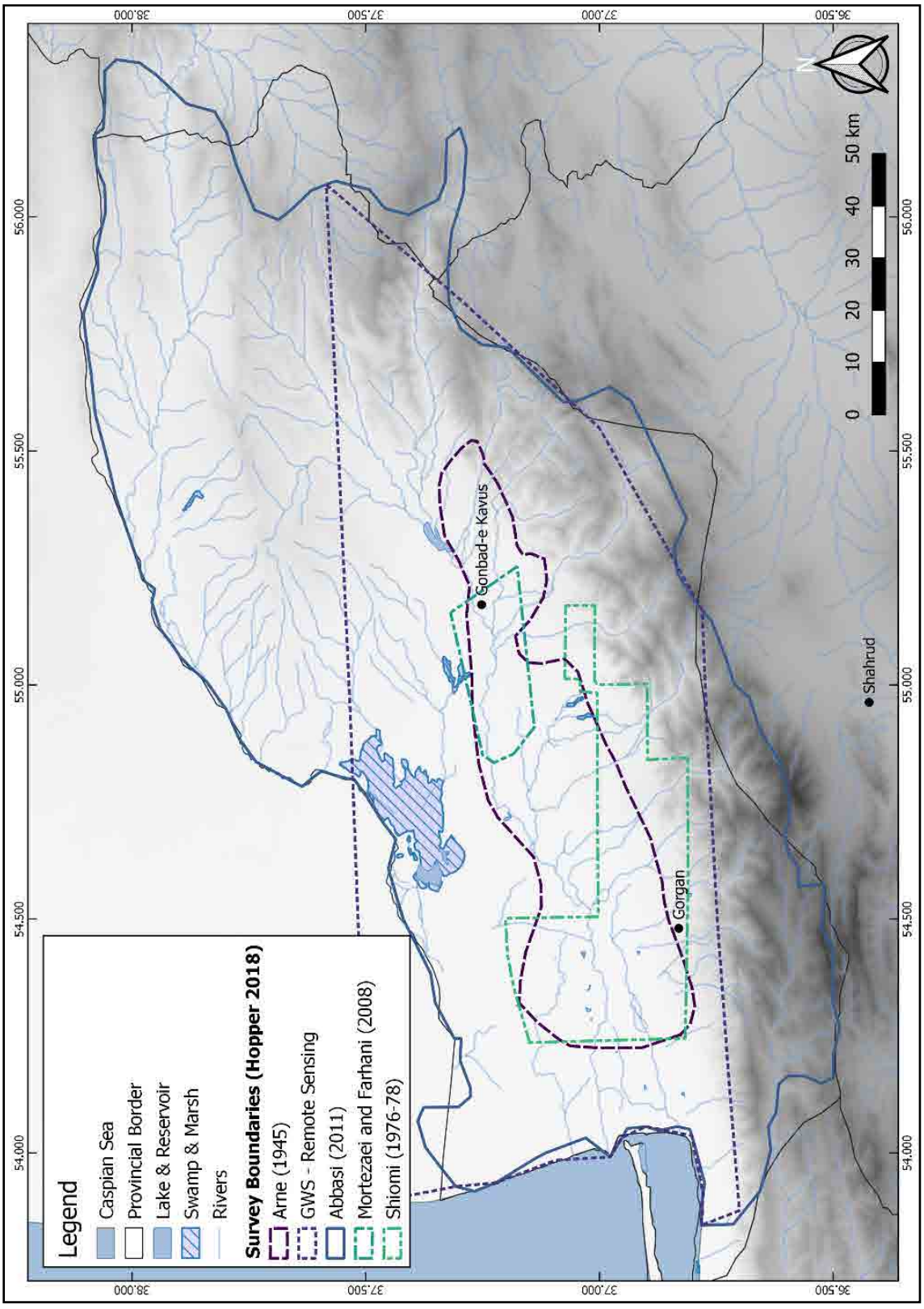

Fig. 1. Map of the Spatial Extent of the Survey Sources (Survey boundary polygons created and generously shared by Dr. Kristen Hopper (pers. comm. 2018).

Table 1. Comparison between the source surveys in terms of Site Description

Survey	Base Measurements	Height Measurements	Graphic Representation of Morphology
Abbasi 2011	None	None	None
Arne 1945	About Half	About Half	About Half (Sketches)
Mortezaei and Farhani 2008	All	All	None
Sauer et al. 2013	More than Half	More than Half	Many (Satellite Imagery)
Shiomi 1974-6	Calculable	All	All
	Morphology Description	**Ground Conditions**	**Chronology Assessment**
Abbasi 2011	None	None	All
Arne 1945	About Half	Infrequent	Infrequent
Mortezaei and Farhani 2008	None	None	All
Sauer et al. 2013	All	All	All
Shiomi 1974-6	All	More Than Half	More Than Half
	Chronology Type	**Surface Remains Described**	**Surface Sherds Depicted in Publication**
Abbasi 2011	1	None	See Abbasi 1394
Arne 1945	3	Less Than Half	No
Mortezaei and Farhani 2008	2	None	No
Sauer et al. 2013	1	All	Less than Half
Shiomi 1974-6	3	More Than Half	No
Key	**Chronology Types**		
1	"Age" System	e.g. Neolithic, Chacolithic, Early Bronze, etc.	
2	"Era" System	e.g. Prehistoric, Historic, Islamic	
3	"Pottery" System	e.g. Painted, Grey, Glazed, Islamic	

Table 2. Aggregate Site Data (All Sources)

Count Type	Count
Unique Sites in Database	1213
Unique Sites Checked in Google Earth	851
Unique Sites Not Checked in Google Earth	363
Unique Sites Checked in Google Earth with Positive Identification	663
Unique Sites Checked in Google Earth without Positive Identification	187
Unique Sites Reported in Multiple Surveys	133
Unique Sites Reported in Multiple Surveys with Positive Identification	129
Unique Sites Reported to date to ca. 3200-1600 BCE	241
Unique Sites Reported to date to ca. 3200-1600 BCE with Positive Identification	184

Additionally, over one-hundred "new" sites were identified through the systematic virtual prospection routine that had not been previously reported by the main sources (Fig. 4). These new site identifications are spread fairly evenly throughout the Alborz Piedmont and the forest-steppe zone between the foothills and the Gorgan Plain River. As with the overall site-database, few of these sites were identified north of the Gorgan Plain river, and surprisingly few tell-settlements were identified in the upland valleys of the Alborz surrounding the plain. The apparent lack of tells in these zones likely results from the fact that settlements in the uplands are by necessity built on or into hillsides and therefore erode at a more rapid rate than in the lowlands. Consequently, in the

Alborz valleys, sites signature that would be readily apparent on the ground are undetectable through visual inspection of satellite photography. Similarly, we should expect that distinct erosional processes north of the Gorgan Plain river are also occluding site-signatures in this area from simple visual inspection of satellite imagery.

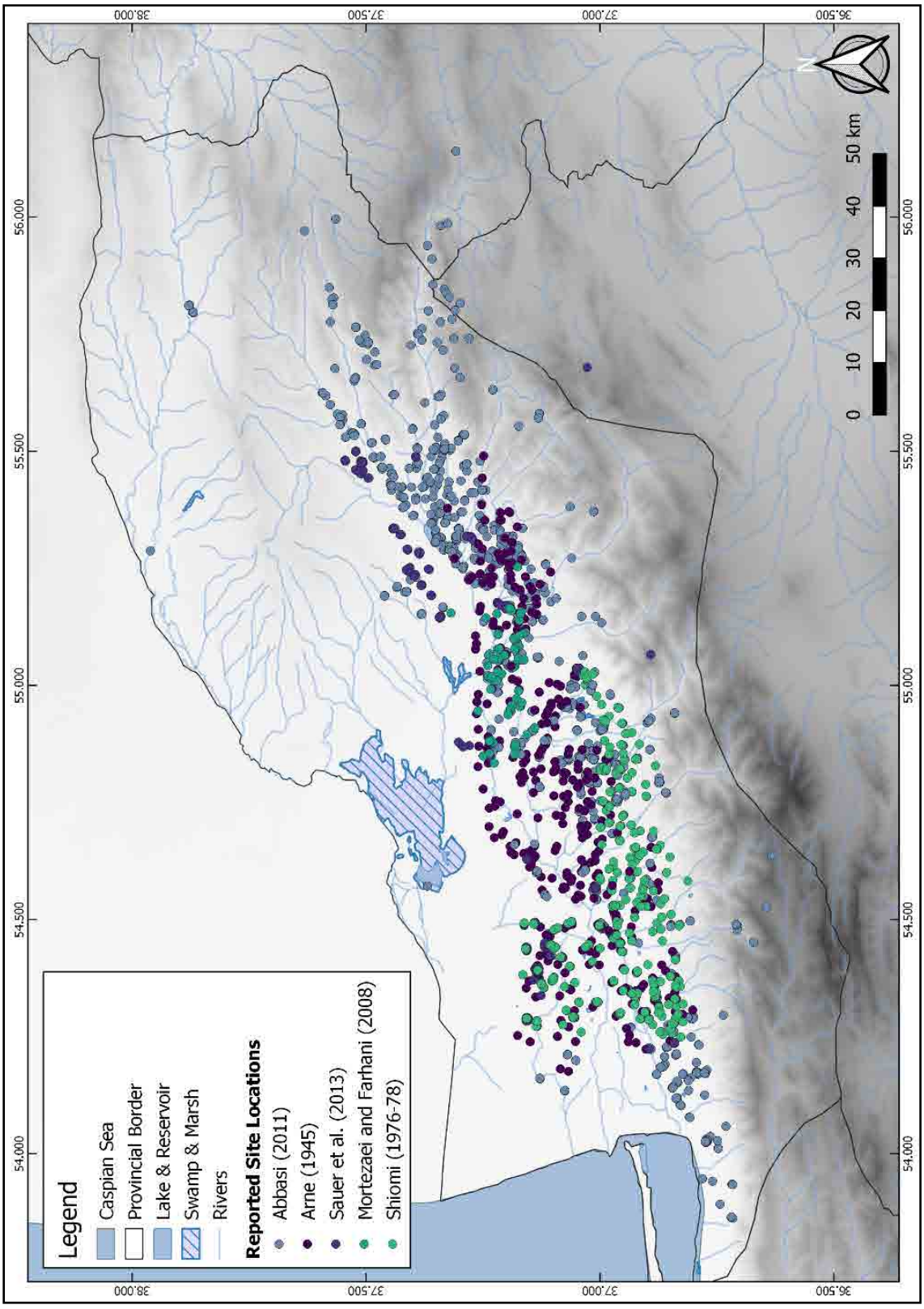

Fig. 2. Reported site locations by source

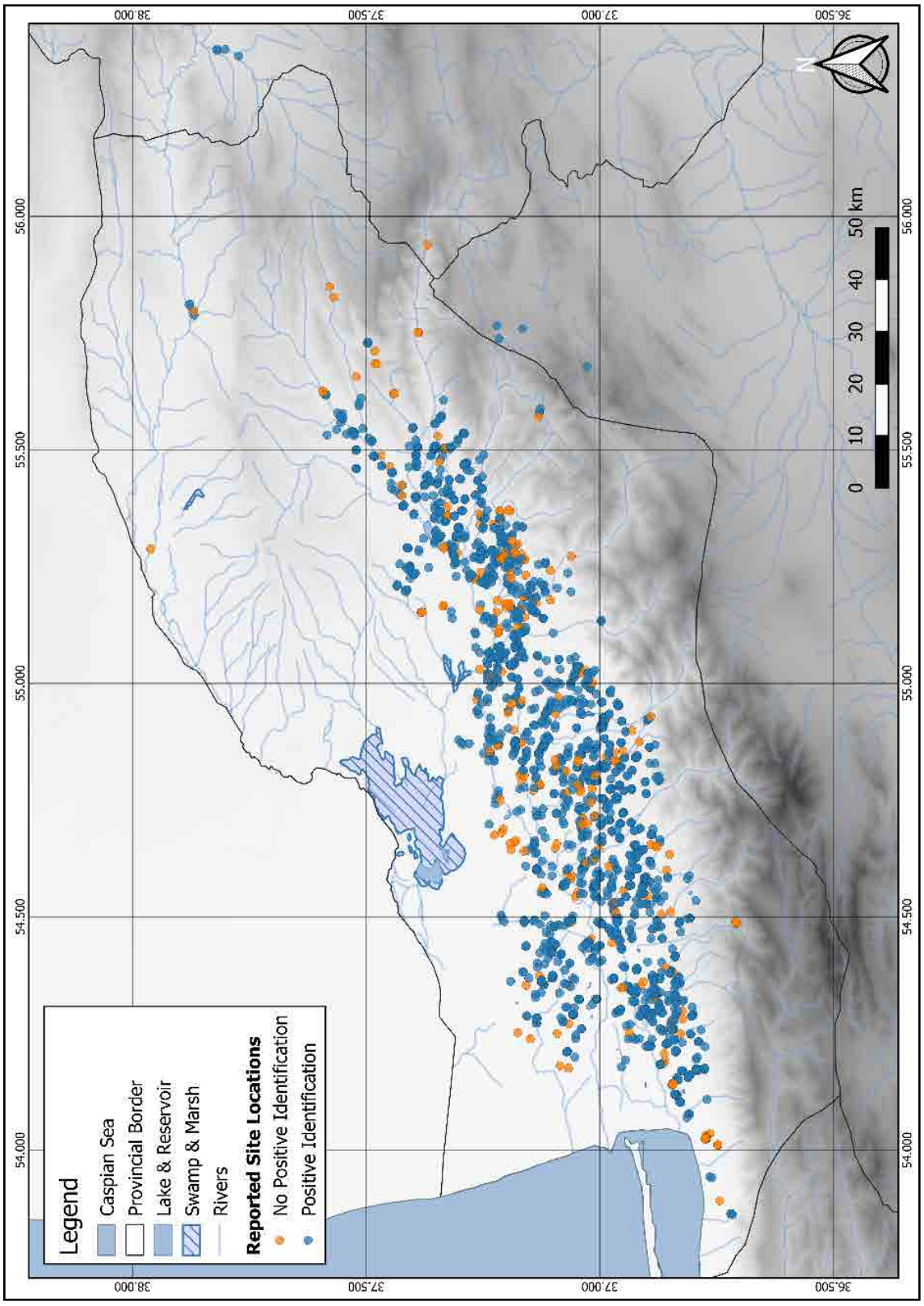

Fig. 3. Geographic Distribution of Positive versus No Positive Identification

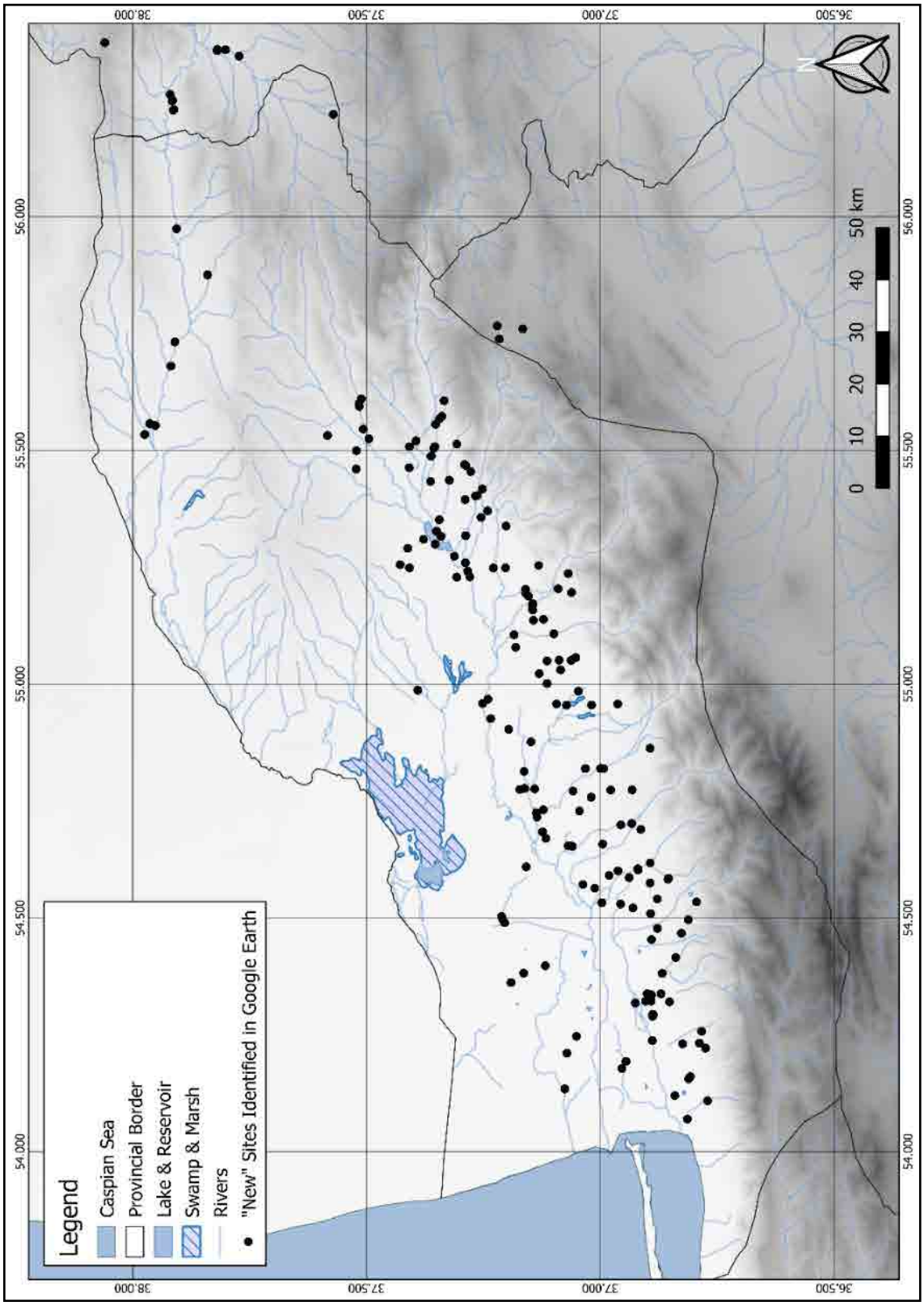

Fig. 4. Geographic Distribution of Previously Unreported Sites Prospected in Google Earth

On the other side of the coin, we must ask why so many "new" sites were identified in areas that were repeatedly surveyed before. Why were these sites not reported in the on-the-ground surveys? Could the translation of data from analog to digital formats be a factor? Or is it the case that previous surveys simply missed numerous sites? What other factors might account for the density of "new" site identifications in repeatedly-surveyed areas? In any case, these "new" site identifications are of great value, as they should be the first stops on future surveys in order to study their surface remains and attempt to assess first and foremost whether they are in fact actually archaeological sites at all, and if they are, to evaluate their chronology and suitability for further investigation.

4. Evaluating Reported Settlement Chronology

In terms of data integration, the temporal dimension of these surveys is perhaps the most challenging. The chronological information presented in the sources is patchy, coarse, and varies considerably in its overall usefulness. At best, the previously reported chronological information can be checked and verified with reference to collections of surface ceramics and excavated materials. At worst, we have to take the chronologies given by previous researchers at face-value. This section presents both the chronological dimension of each of the surveys (and show how this information was incorporated into the GSR database) and the results of analysis of the surface pottery available in both published sources and museum collections.

5. Reported Chronological Information

The chronological information reported from the legacy sources takes one of three forms. In the first, the site data is organized and presented according to chronological criteria (Abbasi), where the site lists and their distribution maps are tied to broad culture-historical periods (e.g., "Chalcolithic" or "Early Bronze Age"). In the second, chronological assessments are appended to site attribute tables (Mortezaei and Farhani, Shiomi), where the assignments may be either culture-historical (e.g., "Bronze Age") or era-based (e.g., "Prehistoric" or "Historic"). The third form is a combination of a matrix that displays the presence/absence and confidence level of different diagnostic ceramic types, accompanied by a narrative description of the surface ceramics (Gorgan Plain Wall Survey). Finally, the Arne survey did not make culture-historical chronological assessments of surveyed sites but did report some general information about potentially diagnostic surface ceramics. It should be noted that the surveys by Arne, Shiomi and the Gorgan Plain Wall Survey have extensive surface ceramic collections; in the case of Arne, restudy of the survey ceramics was conducted specifically for this analysis, and in the case of Shiomi and the Gorgan Wall project, study of these collections is either in press or in progress.

The chronological assessments for this study were first based entirely on the reported information from the published surveys. These reported assessments were limited to only those designations where the sources made an explicit and unambiguous assignment of a particular period to a given site. It should be noted that many sites belong to multiple periods, and that Figure 5 depicts the total number of reported assessments per chronological component in aggregate, not the number of sites. When comparing the distribution of reported chronological assessments to the numbers of sites for which the GSR resulted in a positive site identification, we see that the recovery rate across time periods ranges between 75-90% for each. This is similar enough to the overall average

(ca. 80%) to suggest that positive identification of sites is not biased against sites dating to any particular period during this interval.

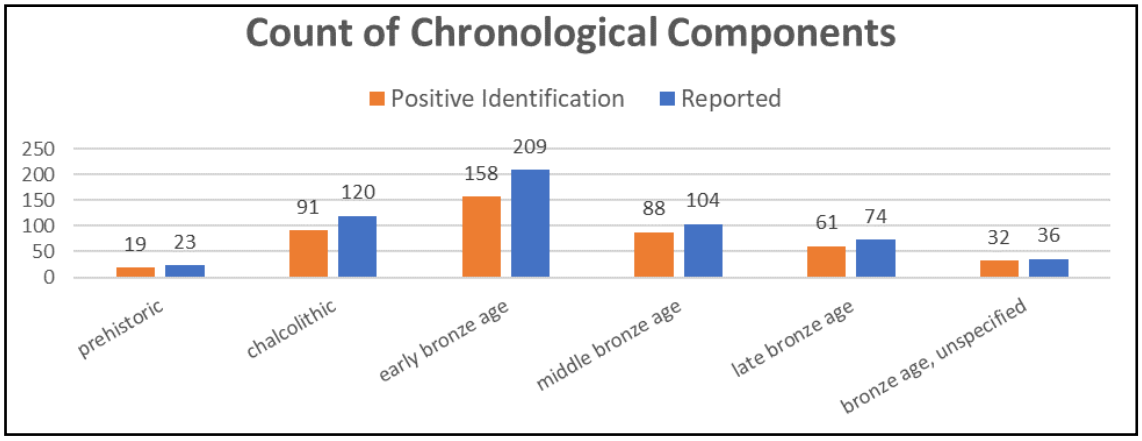

Fig. 5. Counts of Sites by Chronological Categories and Positive Identification

Another important dimension of the chronological assessments is their distribution across the legacy sources. With only a few exceptions, most (462/501 or 92%) of the chronological assessments of the Chalcolithic through Late Bronze Age are reported from just one source (Abbasi). A small number of sites can be considered to be "reported" to date to the Chalcolithic on the basis of textual description of diagnostic ceramic types, particularly Caspian Black on Red Ware, in the sources (Arne, Mortezaei and Farhani, and Shiomi). The remainder of the sources either report general assessments of sites as belonging to the Bronze Age, or else are designated as merely Prehistoric. The operational definitions of what these periods correspond to is presented below.

The reported chronological information presented above can be further refined with reference to the surface ceramics collected by these surveys, which are all incompletely published (e.g., Arne 1935, 1945: 21-22; Bylin-Althyn 1937; Ohtsu *et al.,* 2010, 2012; Sauer *et al.,* 2013: 102-125). Further analysis should focus on tracking down whatever records underpin Abbasi's chronology, any photographs and field documentation of surface ceramics collected by the Gorgan Plain Wall Survey project, and to contact the keepers of the Shiomi surface ceramics collections, which are split between Tehran and Hiroshima. Until then, what little information is presently available is described below.

6. Recorded Chronological Information

Both the published and unpublished surface ceramics are few in number. On the published side, there are only three publications that present images of diagnostic surface pottery explicitly linked to a single site (Abbasi 2016; Ohtsu *et al.,* 2010, 2012). On the unpublished side there are several collections, but only one was available for the purposes of this analysis (i.e., Arne). For both published and unpublished collections, the diagnostic material often amounts to a single sherd; unfortunately, this diminishes the confidence we may put in these chronological determinations, but as is often the case with legacy data, you must start with what is available. In other cases, there is much more material, but it is not always particularly diagnostic of a single period as certain common forms of pottery were in use for long periods of time.

This analysis of published and unpublished surface ceramics resulted in the recording of a chronological determination for 52 sites (Table 3). Given the discrepancies surrounding

the identification of particular ceramic types described above and the major disjunctures in understandings of the relationships between strata at key excavated sites and the 3-age system for the region, it is reasonable to ask whether these recorded designations can be used alongside the reported chronologies in any straightforward fashion.

Table 3. Recorded Chronological Determinations by Source and Period

	Chalcolithic	***Early Bronze Age***	***Middle Bronze Age***	***Total***
Abbasi, 2016: 138, Fig. 102	27	0	0	27
Arne Collections in Sweden	13	7	0	20
Ohtsu et al., 2012: Plates I-III	3	1	1	5
Total	**43**	**8**	**1**	**52**

The major remaining chronological concern is the status of the sites designated "Early Bronze Age" in Abbasi's gazetteer, which he designates as Narges IIIc and Torang IIA-IIB (2011: 240-241; 2016: 6). This is an unfortunately incorrect correlation between site-strata and culture-historical eras. Indeed, Narges IIIc clearly belongs to the Chalcolithic and Abbasi dates this to the second quarter of the 4th millennium (Abbasi 2011: 241). Moreover, Abbasi's description of the ceramics of Narges IIIc are clearly those of Torang IIA-IIB, including short and squat slightly carinated jars, as well grey-black sherds with appliqué ridges, knobs, incised grooves, and combinations of the three along with Black on Red Painted Ware, which is described as burnished, which we can comfortably identify as Caspian Black on Red rather than Aq II. He also claims that many of the Narges IIIc finds have great similarities to Shah III-IIb, whose "proposed chronology is the second half of the 4th millennium" (Abbasi 2011: 241). Thus, Abbasi has clearly conflated the Early Bronze Age and the Chalcolithic, which is plain to see from his chronograms, where he consistently and incorrectly designates Torang IIA-IIB as Early Bronze Age (2016: 6). Curiously, however, when surface ceramics are presented as photographs or illustrations, they are generally assigned to the correct era (e.g., Abbasi 2016: 139, Fig. 102). Yet, there is no evidence to suggest that the site chronology presented in Abbasi's gazetteer is based on a detailed or systematic examination of the surface finds from the sites listed and thus seems more likely to comprise a re-presentation of information contained in other reports. The conflation of the Early Bronze Age and Chalcolithic strata and pottery types in the text of the gazetteer seems therefore unlikely to have been propagated. The best course of action, therefore, is to treat the reported information as if it were correct, with the full knowledge that this cannot be verified without reference to the source reports and collections.

Other concerns with the recorded chronological framework include: the flattening of the Chalcolithic period into one phase and the generally non-diagnostic character of much of the published survey pottery from the Shiomi survey and the Arne collection. For example, the distinction between Aq II and Caspian Black on Red Ware is an important one temporally, but which has escaped all previous authors as a salient chronological diagnostic. Therefore, while this distinction can be maintained in materials to which the present author has had access, it is not present in any of the other sources and thus not operationalizable for analysis at present. The confidence threshold required for these materials to be included in the sample under analysis was therefore quite strict, thus greatly reducing the size of the analytical sample compared to what is potentially available. The

sample can only be increased with reference to a larger and more diagnostic sample of surface pottery, to say nothing of the benefits that a larger sample of stratigraphically controlled excavated material would provide. In summary, the reported and recorded chronological information may be provisionally treated as analytically compatible, with the full knowledge that both the frameworks themselves and the correlation between them are provisional and likely subject to substantial future revisions.

7.Chalcolithic and Bronze Age Settlement Patterns of the Gorgan Plain

With all the preceding information about the nature and quality of the spatial and chronological data from both the reported survey data and my restudy protocol, we can examine the basic organization of the settlement distribution of the Gorgan Plain and how it changes over the course of the third millennium. The analysis of the settlement patterns begins by specifying the quantitative parameters of the sample to be analyzed (i.e., only those sites for which a positive identification was made during the Gorgan Plain Survey Restudy), and then examining the spatial distribution of site counts over time. Then the intersection of chronology and site size (i.e., base area in hectares) is analyzed, before re-introducing location to the analysis.

8.Site Size Distributions Over Time

While site size is reported in a number of formats across the sources, the one constant measurement present in all surveys is base area. Moreover, base area can be measured in Google Earth by drawing a polygon around the boundary of the site and measuring that polygon. This is likely not the most accurate method of measurement, but there are few reasons to believe that field measurements derived from the use of analog theodolites between forty to eighty years ago would be any more or less reliable. The following charts represent five different ways of visualizing key basic descriptive parameters of the distribution of site sizes over time without considering location.

The overall distribution of base area measurements does not change dramatically in its overall shape between the four time periods (Fig. 6). First, and most simply, the minimum and maximum base area measurements hold constant over these four periods. This can be explained with reference to two observations: (1) in each period there is at least one site sized 0.1 ha or less, and (2) the base-area estimate for Torang Tappeh cannot be chronologically subdivided on the basis of presently available information. It seems unlikely that Torang Tappeh covered 34 ha for the entirety of its prehistoric occupation, and indeed may be smaller or in fact even larger at different intervals. Moving away from their extremities, the most notable feature of these distributions is their strong skew toward the lower end of the size spectrum, with the plurality of sites in each period smaller than 3 ha in all periods. The distribution of larger sites (outlier points on the plot) does change between the periods, with a significant increase in the number of sites larger than 5 ha during the Early Bronze Age, and a decline in the numbers of sites larger than 5 ha from the Early Bronze Age to the Middle Bronze Age and from the Middle Bronze Age to the Late Bronze Age.

The site-size distributions are visualized in the form of a histogram in Figure 7, which goes some way toward disaggregating the summary presented in Figure 6. What it most clearly shows is both the numerical dominance and the changing proportion of sites whose base area measures between 1.0 and 2.0 over time. Additionally, it provides

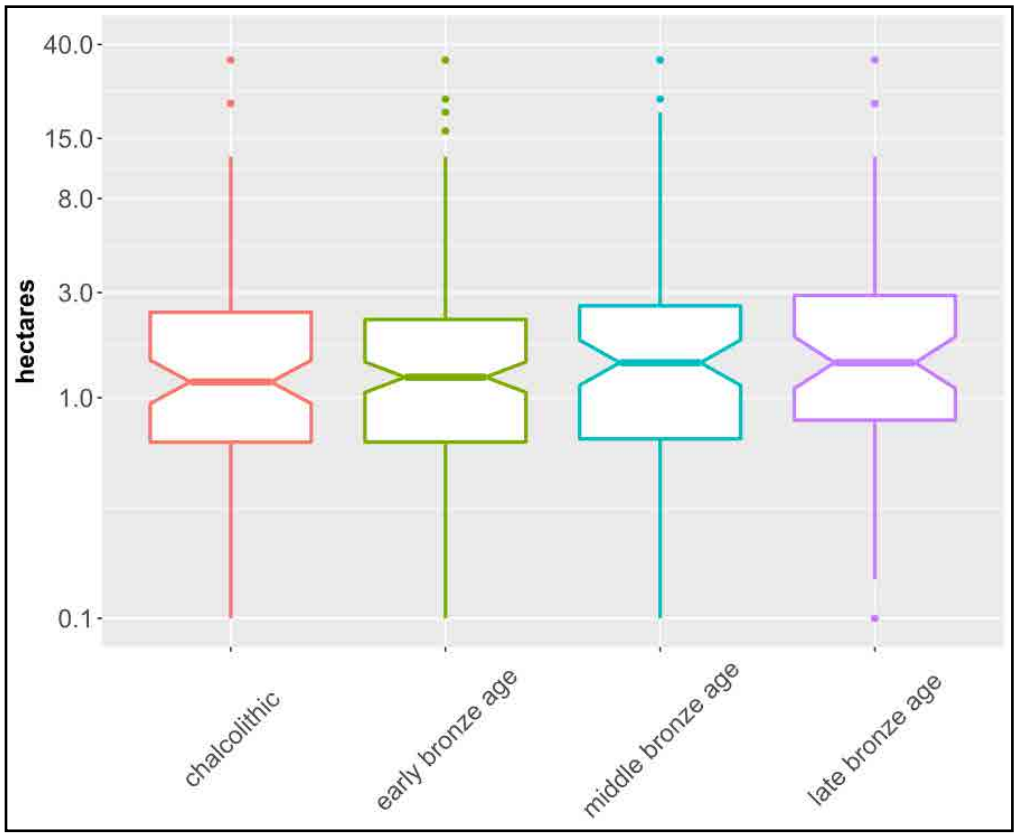

Fig. 6. Box-and-Whisker Plot of Site Size Distribution Grouped by Period (Scaled log10)

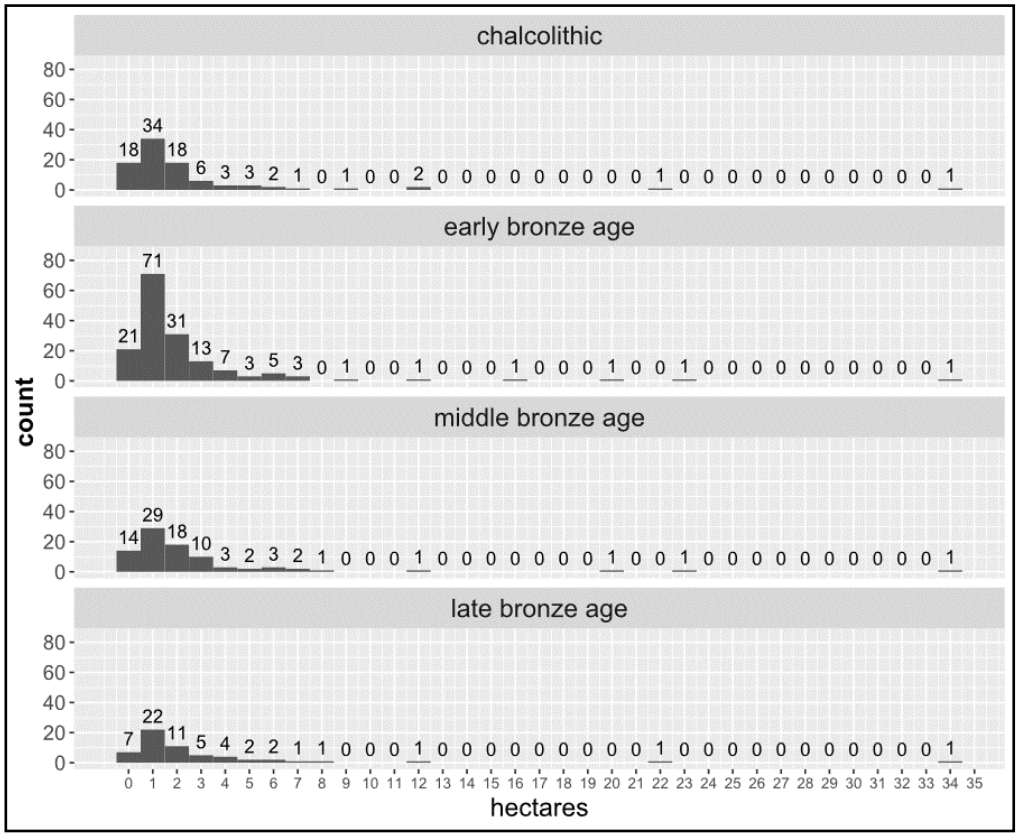

Fig. 7 Histogram of Site Size Distribution Grouped by Period

an alternative way of viewing the distribution of the medium- and large-sized sites. Particularly noticeable from this chart is the small number of sites in all periods the larger than 10 ha; there are 4 in the Late Chalcolithic, 5 in the Early Bronze Age, 4 in the Middle Bronze Age, and only 3 in the Late Bronze Age.

Fig. 8 re-aggregates the size distributions, for the purpose of examining the median, mean and sum of site sizes over time. While it is clear from Figures 6 and 7 is that the overall distribution of site sizes is skewed strongly toward the lower end of the spectrum (i.e., smaller sites are more common than larger sites), there are also more subtle trends that can be observed in median and average site base area over the four periods. Principally, there is an increase in the median site base area from 1.15 ha in the Chalcolithic to 1.24 ha in the Early Bronze Age, followed by another increase to 1.45 ha in the Middle Bronze Age, which holds constant to the Late Bronze Age. The trendline of the mean site base area is similarly shaped, rising from 2.49 ha in the Chalcolithic to 3.04 ha in the Late Bronze Age, a percent increase (22.1%) roughly comparable to that over the same interval in the median size (26.9%). The trajectory of mean site-size differs, however, in that the mean site base area drops from the Chalcolithic to the Early Bronze Age, likely due to the doubling of the number of sites between 1-2 ha in size between these two periods, before rising more sharply between the Early Bronze Age and Middle Bronze Age.

In terms of aggregate site base area over time, there is a noticeable increase from the Chalcolithic to the Early Bronze Age (i.e., from 224 to 372 ha, an increase of 166%), followed by a 35% decrease to 242 ha in the Middle Bronze Age and a further 28% decrease to 176 ha in the Late Bronze Age. The aggregate base area figures are partly a factor of the raw counts of numbers of sites, which show the same distribution (i.e., Fig. 5), but are also affected by the aforementioned trend toward slightly larger median and average site sizes over time. Thus, the main trend over time appears to be overall growth from the Chalcolithic to the Early Bronze Age, both in terms of aggregate occupied hectarage and number of sites, followed by two successive periods in which the total number of sites and aggregate occupied hectarage declines.

SV = Small Village (0-3 ha); LV = Large Village (3-8 ha); ST = Small Town (8-15 ha); LT = Large Town (15-40 ha)

Fig. 9 presents another way of breaking down the changes in settlement demography by computing the proportions that different size classes of sites contribute to the overall count (left) and aggregate occupied area over time (right). With regard to small villages (i.e., sites between 0.1-3 ha, shown in purple), these contribute the overwhelming plurality of site counts in all periods (consistently between 78-84%), but their proportional contribution to the total occupied area exhibits more variation from period-to-period. To wit, after increasing from the Late Chalcolithic to the Early Bronze Age, the proportion of the aggregate settled hectarage contributed by small villages decreases from the Early to Middle Bronze Age and again from the Middle Bronze Age to the Late Bronze Age. It is a significant result that during the Early Bronze Age 84% of the sites were small villages and that these sites contributed 43% of the total occupied area in the region but that by the Late Bronze Age these figures had declined to 78% of the total sites being small villages but only contributing 33% of the total occupied area.

As regards large villages (i.e., sites between 3-8 ha, shown in green in Fig. 9), the proportion that these sites contribute to the total of both site counts and aggregate occupied area increases period-to-period over the entire span. The numerical proportion

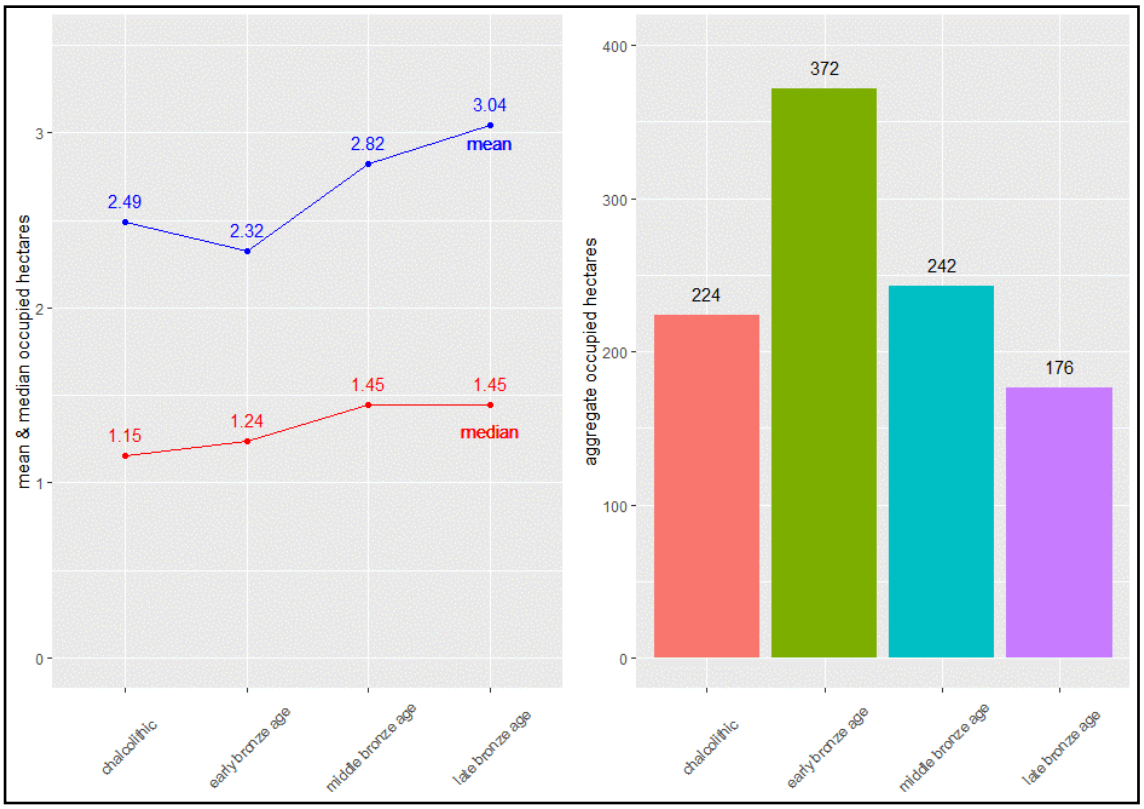

Fig. 8. Descriptive Statistics (Mean, Median, and Aggregate Occupied hectares by Period)

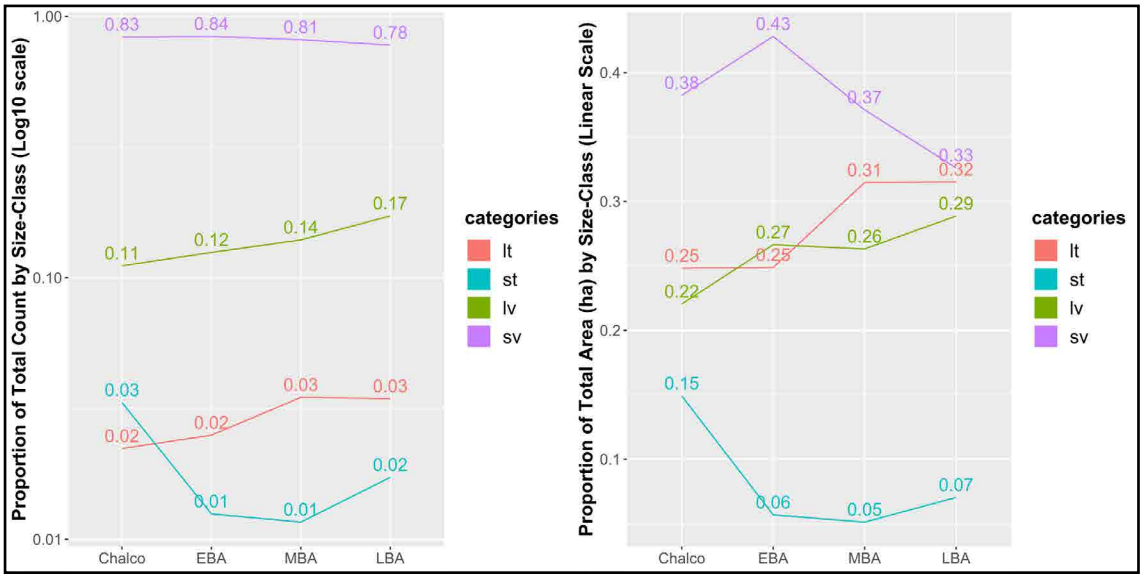

Fig. 9. Population Distribution between Large and Small Settlements Over Time

of large villages relative to the overall sample increases from 11% in the Chalcolithic to 17% in the Late Bronze Age. In terms of the contribution that large villages make to the overall occupied area, this proportion increases from the Chalcolithic to Early Bronze Age (22% to 27%), remains basically the same from the Early to Middle Bronze Age, before increasing again to 29% in the Late Bronze Age. Thus, over time, large villages become more prevalent and constitute a larger proportion of the population of the region.

Small towns (i.e., sites between 8-15 ha, shown in blue) contribute a low percentage of the count and aggregate area in all periods. Their greatest proportional prevalence is in the Late Chalcolithic and in the Late Bronze Age, but at no point is this figure greater than 3% of the total number of sites. Most interestingly, during the Chalcolithic, small towns contribute 15% of the aggregate occupied hectarage of the region, but never more than half of that figure in any of the subsequent periods. Nevertheless, the numerical proportion and proportion of aggregate occupied area increase from the Middle Bronze Age to the Late Bronze Age, though in both of these periods, small towns are the least frequent size-class and constitute the smallest proportion of the total occupied area.

The large towns (i.e., sites between 15-40 ha, shown in red) are a bit trickier to interpret, given what we know and don't know about the change in size of Torang Tappeh over time, but given this caveat, the notable trends are that they contribute a small proportion of the total site count in all periods (in no period are there more than four such sites), but their proportion of the overall aggregate area is consistently between one-quarter and one-third of the total. Between the Chalcolithic and Early Bronze Age, the proportion of aggregate area holds at 25%, and increases through the Middle Bronze Age to 32% in the Late Bronze Age.

Now, of course taking base area measurements as corresponding to occupied hectarage is not an unproblematic assumption, nor is taking occupied hectarage as a proxy for population/demographic trends (Drennan *et al.,* 2015). In the absence of better sources of population proxies, we have to make do with what information is available. Nevertheless, several clear trends can be observed via simple population distribution proxies. Most notable among these are: 1) a large increase in overall settled area from the Chalcolithic to the Early Bronze Age, which appears to be due to an increase in the total number of sites, but especially from growth in the number sites sized between 1-2 ha and 5-10 ha; and 2) a restructuring of the "demographic profile" from the Early to Middle Bronze Age, where the average and median site sizes increase, but the overall count of sites and occupied hectarage decreases, a trend which continues into the Late Bronze Age. This change appears to be due to the increase over time in both the numerical and areal proportion of large villages relative to the aggregate (Fig. 9). Another significant trend to observe is the convergence in areal proportion contributed to the total by large towns, large villages, and small villages in the Late Bronze Age, where they are almost the same, despite their numerical-proportional differences. This suggests that during this time, the population concentrated especially in a greater number of large villages as compared to before. Whether this represents stability and growth in sites established in the Middle Bronze Age or an entirely different pattern of agglomeration will remain the subject of future inquiries.

In summary, it appears that the greatest proportion of the population of the Gorgan Plain lived in small villages in all periods considered here. However, the proportion of the population living in large villages, small towns, and large towns steadily increased period-over-period across this interval until the Late Bronze Age, when the aggregate occupied hectarage was nearly equally comprised of small villages, large villages and large towns. The change in site-size distributions over time discussed above are interesting in their own right but become all the more compelling when the third key variable (location) is re-introduced.

9. Site Location Distribution Over Time

There are several notable patterns in the spatial distribution of sites in the Gorgan Plain during this period. First and foremost, there appear to be three distinct zones of settlement, one in the west of the plain, one in the central plain, and another in the east. Additionally, site locations appear to shift steadily southward over time. And finally and most curiously, in all four periods there appears to be a spatial gap between the central and eastern portions of the plain where there are no reported or recorded site locations (see: Figs. 10-13). This "gap" may be misleading, however, as the GSR protocol documented at least nine mounded sites in this area during the process of reviewing the reported site locations in Google Earth and there are likely more yet to be found; moreover, a large number of later sites are reported in this location by Abbasi. Perhaps this gap is the result of access to this area being restricted for fieldworkers, as it is not covered by any of the intensive on-the-ground surveys (see: Fig. 1). In the satellite imagery, it does not appear unusual in any way such to suggest modern climate or topographic conditions occluded archaeological visibility, and it is bounded on all sides by inter-city roads and the province's main arterial highway.

With respect to the size-location distribution of sites dated to the Chalcolithic, the focus of occupation seems to be concentrated at opposite ends of the plain. The number of sites appears to be about equivalent between the western and eastern halves of the plain, but the size distribution differs. During this period, the western half of the plain appears to be more split between large and small sites. Both of the 15+ ha sites are in the western plain, but with only one 8-15 ha sized site and four 3-8 ha sized sites and the remaining under 3 ha. In the eastern half of the plain there are no 15+ ha sites, but more 8-15 ha sized sites and the same number of 3-8 ha sites.

Settlement also appears to be more spatially concentrated in the eastern half of the plain as compared to the west, where there is more average distance between the sites. In both cases, and as will be seen throughout the following examples, settlement tends to cluster quite closely to permanently watered rivers and streams.

In the Early Bronze Age, the division between the western and eastern halves of the plain is less clear-cut, especially as there is more settlement along the Kara Su River in the far west of the plain, compared to in the Chalcolithic. The notable change in the settlement distribution (in addition to the notable increase in numbers and sizes of sites overall) is that settlement considerably expands in the central part of the plain (near the intersection of 37.00° Lat, 55.00° Long), with a large number of new small sites, but also several larger sites of different size classes as well, including two new sites >20ha. The site distribution in the eastern plain changes as well, with the core area from the Chalcolithic still densely populated with sites, but with some expansion in the number of sites, particularly to the south of the modern reservoir. A new intermediate-sized site appears just north of the Gorgan Plain River during this period, and one of the older intermediate-sized sites from the Chalcolithic appears to grow considerably in size.

In the Middle Bronze Age, the most notable change is in the marked decrease in the number of sites overall. Most of the intermediate- and large-sized sites are still occupied, but the number of small settlements surrounding them is noticeably less. In particular, the number of sites in the central and especially the eastern parts of the plain appear to be considerably reduced compared to the preceding period. The western-most part of the plain, by contrast, appears relatively stable though some small sites from the previous

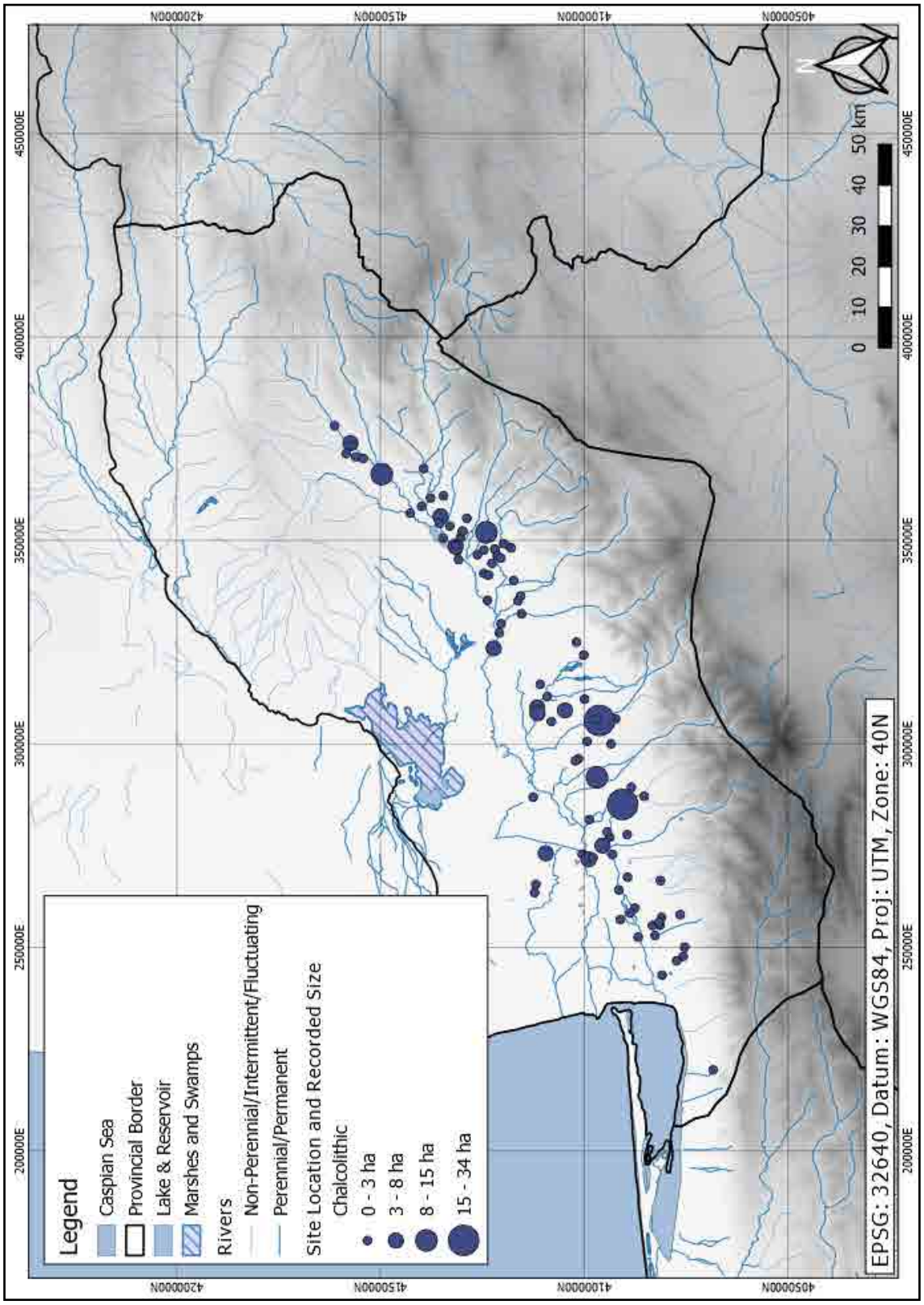

Fig. 10. Geographic Distribution of Site Size Classes (Chalcolithic)

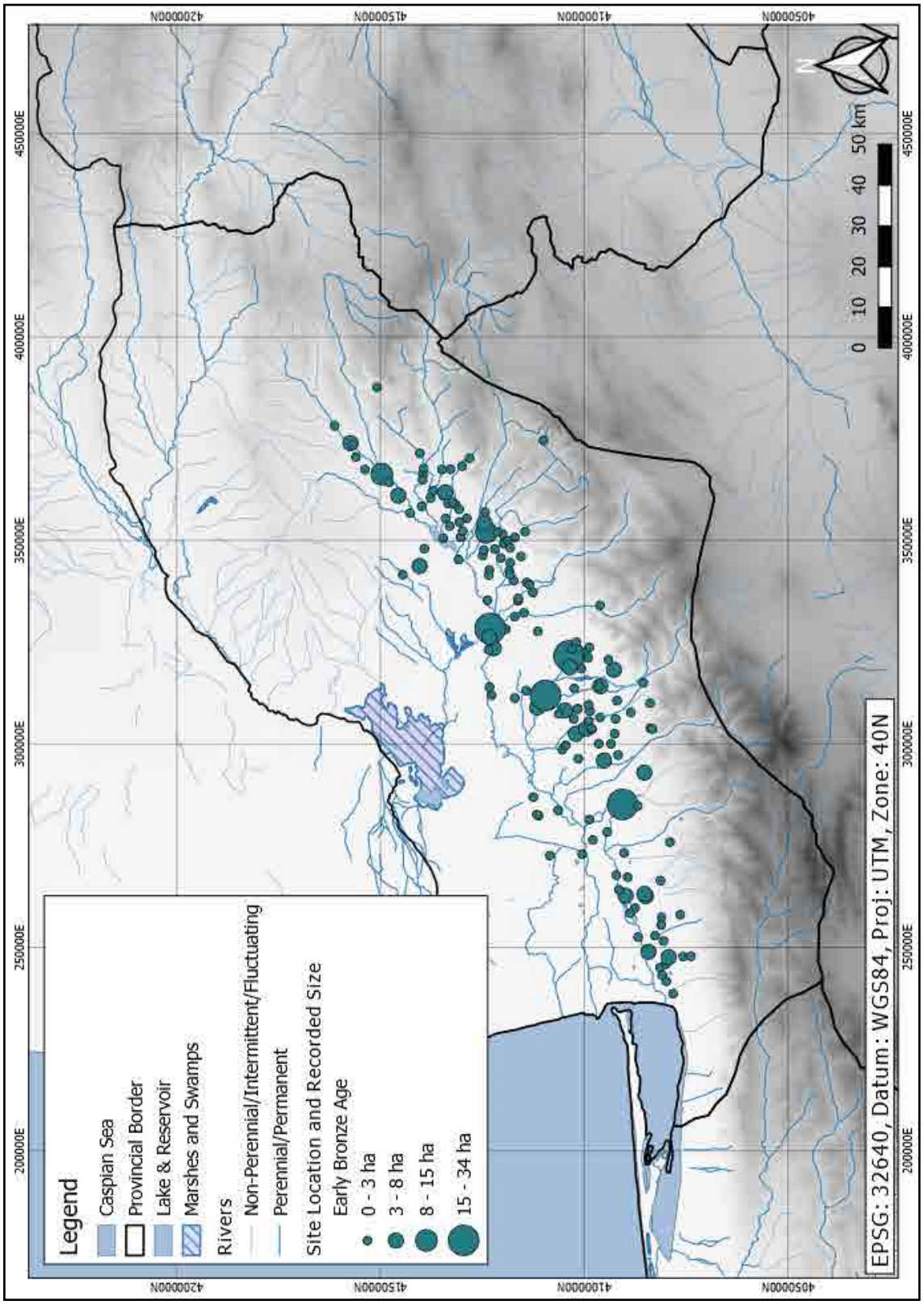

Fig. 11. Geographic Distribution of Site Size Classes (Early Bronze Age)

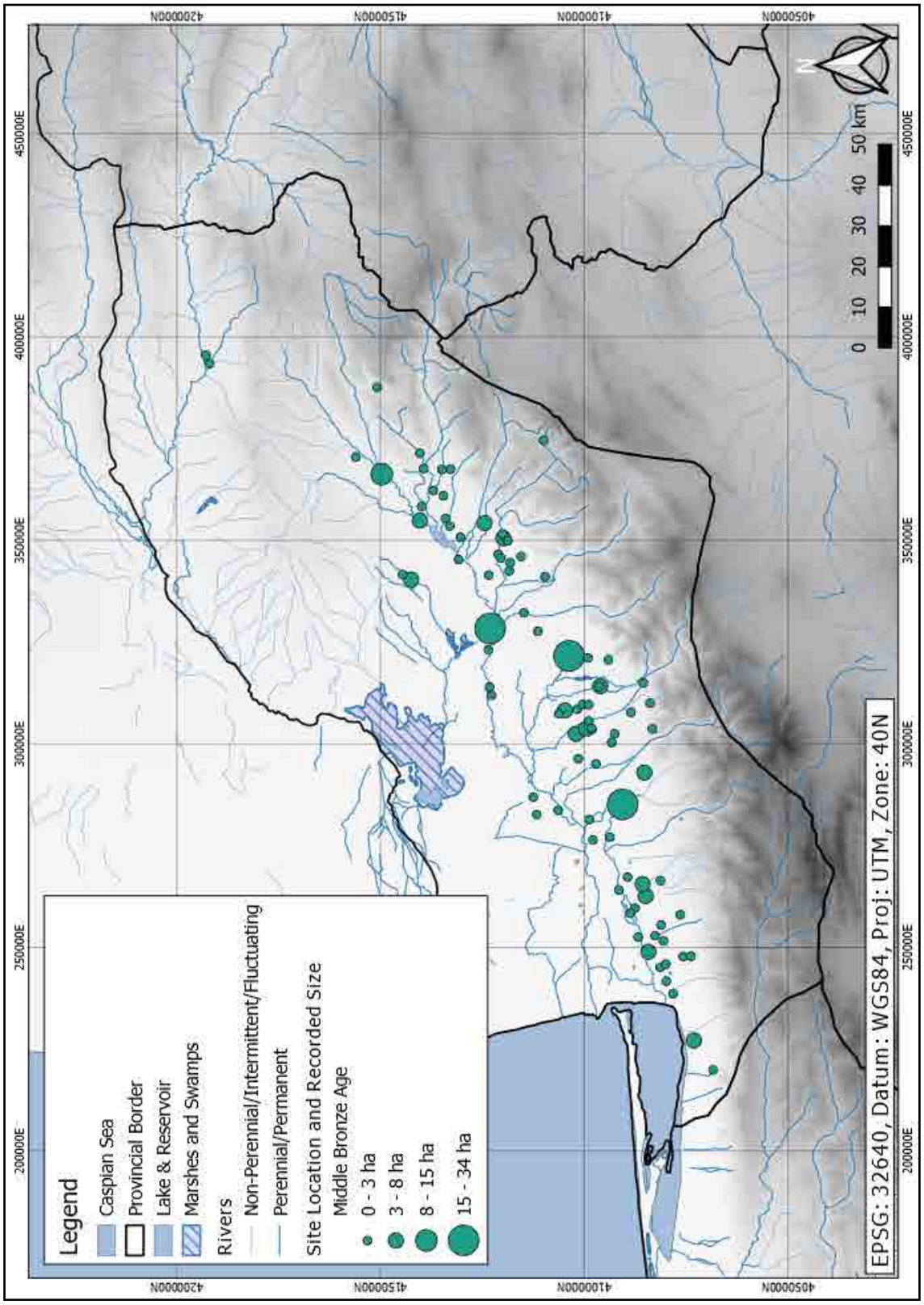

Fig. 12 Geographic Distribution of Site Size Classes (Middle Bronze Age)

period do not continue to be occupied. There is also one fewer site in the largest site-size class in the Middle Bronze Age (n=3) as compared to the Early Bronze Age (n=4), but the three that remain were continuous occupations from the EBA, rather than new settlements.

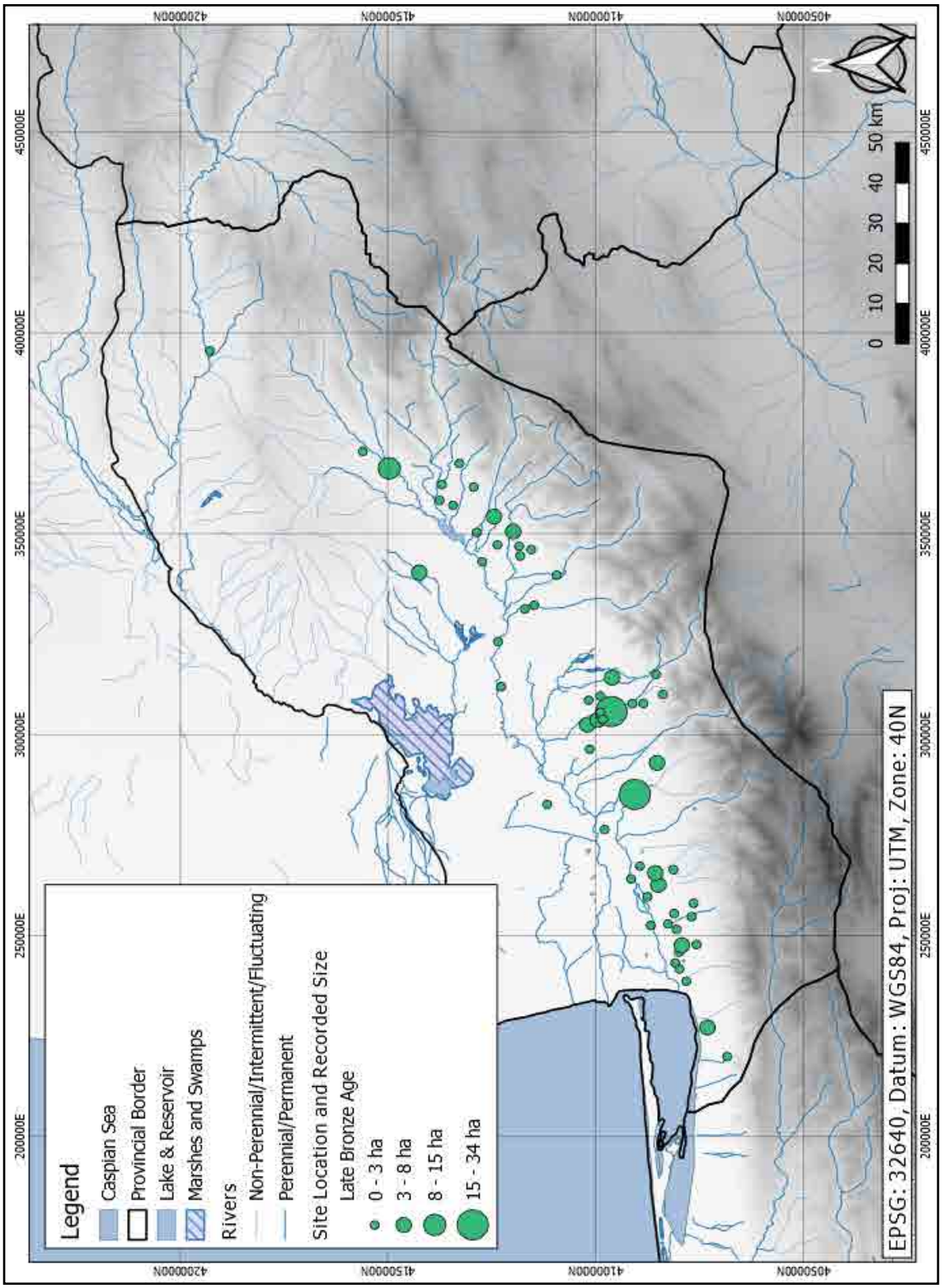

Fig. 13. Geographic Distribution of Site Size Classes (Late Bronze Age)

During the Late Bronze Age, the trend toward the reduction in site numbers continues, however some interesting spatial trends emerge. In the westernmost part of the plain, there are no sites larger than 8 ha, but this area has more 3-8 ha sized sites than the other two zones. The central zone continuing to be home to the largest centers, as in the preceding period, with the two 15+ ha sized sites located here; in contrast to previously, however, there are no 8-15 ha sized sites in this zone during this period. In the eastern plain, there is one site sized 8-15 ha and three sites sized 3-8 ha. Settlement appears densest in the central plain and concentrated along a single river channel. Settlement is least dense in the eastern zone of the plain, which is a new development compared to previous periods.

To summarize, the Gorgan Plain's settlement patterns differ from the macro-region as a whole. Whether we agree with Tosi's model for the overall region of the "Lands East of Sumer"—i.e., that during the late fourth to early third millennium some of the villages in greater Khorasan grew into towns and became centers of more advanced craft production as well as the central nodes in emergent networks of cultural integration, followed by the early-to-mid-3rd millennium, when some of these towns grew into proto-urban centers, which were larger and more complex settlements within which markers of social differentiation were increasingly observed, which continued to extend their cultural influence over ever larger territories (Tosi 1986: 158), culminating in the formerly proto-urban centers developing into fully urban cities, attaining their maximal territorial hegemony, and exhibiting increasingly hierarchical social complexity by the mid-to-late-3rd millennium (Tosi 1974, 1977), before collapsing by the turn of the second millennium, marked by the rapid decline in size and complexity of the central sites and a breakdown in regional-scale cultural integration (Biscione 1977; Tosi 1986: 158; cf. Hiebert 1994; Kohl 1984, 2007)—the evidence presented here presents a dense record of settlement primarily comprising small villages and towns with little evidence for proto-urbanism aside from at Torang Tappeh. Thus, settlement patterns represent another point of distinction that mark the Gorgan Plain as unique among the regions of Eastern Iran, southern Central Asia, Afghanistan, and the Indo-Iranian borderlands. In particular, the Gorgan Plain exhibits its greatest number of sites, largest amount of occupied area, and highest number of possible "centers" during the Early Bronze Age, i.e., earlier than predicted by Tosi's model, which would expect these figures to characterize the Middle Bronze Age. The Late Bronze Age of the Gorgan Plain also departs from Tosi's prediction, in that while there does appear to be a decline in population (understood through the rough proxy of site counts and aggregate occupied area), it is hardly the case that this is the result of the disappearance of centrality; indeed, settlement appears to concentrate to a greater degree than before in large villages and large towns.

Finally, it should also be noted that the sites tend to be located further south over time (Fig. 14). The northern and southern limits of the settlement distribution are relatively stable over time, which is unsurprising given the ecological barriers (i.e. the Turkmen Sahra to the north and the Alborz Mountains to the south). The mean, as well as the second and third quartiles, move steadily southward over time, however. This is an interesting observation, but one which is likely to be related to environmental factors beyond the scope of this analysis. Nevertheless, investigation into the causes and impacts of this shift are certainly an area for further research, especially in light of the increasingly detailed paleoclimatic and geomorphological record available for the Caspian basin more generally, but the southern littoral in particular (see Leroy *et al.,* 2019; Shumilovskikh

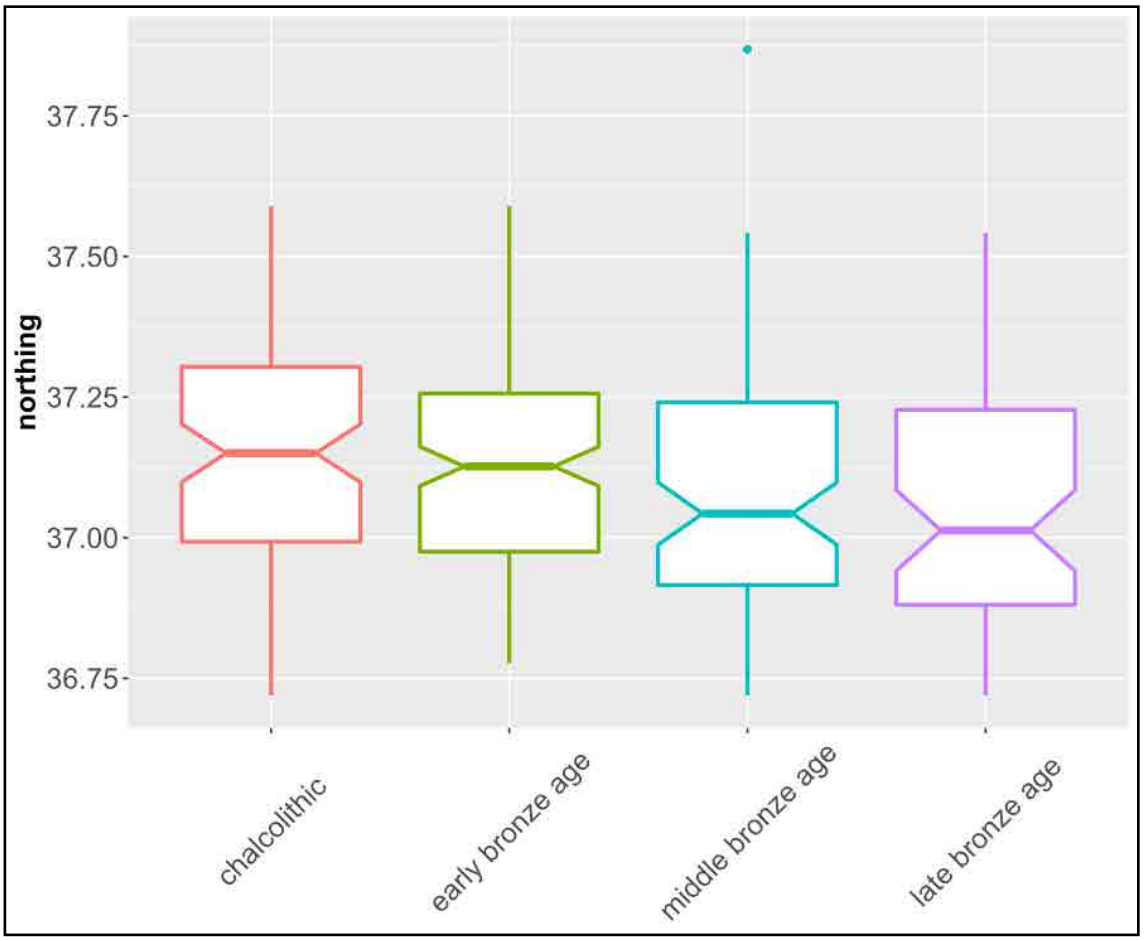

Fig. 14. Southward shift in Settlement Distribution over time

et al., 2016). This could perhaps be connected to Ali Mousavi's hypothesis about changing patterns of resource use and the availability in particular of fuel for ceramic and metallurgical production (Mousavi 2008). Could the shift of settlement southward over time be caused by the increased need for and decreasing supply of timber reserves? Could it also be related to the effects of the 4.2ka climate event (Helama 2024; Kaniewski *et al.,* 2008; Ran and Chen 2019; Weiss 2012)? Or some combination of all three, and potentially more, factors?

10. Conclusion

In this paper, the Chalcolithic and Bronze Age settlement record of the Gorgan Plain has been analyzed as an integrated regional dataset for the first time. This complex landscape of tells has been surveyed multiple times over the course of the past eighty years. These survey records vary in their quality and reliability, but digitization of paper records and the conversion of the flat tables of the source information into a relational geospatial database was augmented by the Gorgan Plain Survey Restudy protocol. While the quantitative analytical methods used in this paper are relatively simple, they constitute the necessary first steps toward more sophisticated investigations. Indeed, prior to this analysis, the main observation that could be made about the settlement patterns of the Gorgan Plain is that the region contained between 200-300 sites dating to the third millennium. Through the application of basic Exploratory Data Analysis techniques—including summary statistics

of site-sizes through box-and-whisker plots and histograms, along with the computation of the changing proportions of counts and area contributed to the total by sites of different size classes and visual inspection of distribution maps—we now have a much better sense of the subtleties of historical and spatial trends of settlement in the Gorgan Plain during the Chalcolithic and Bronze Age.

Finally, a surprising result was the discovery that site locations steadily trend southward over time, which remains to be explained, but may perhaps be due to changing patterns of resource use or climate shifts. Indeed, the question of climate change and its impact on settlement in the Gorgan Plain is an important one for three reasons. First, the Caspian Sea experienced a low-stand between ca. 7-3.5kya, with a minimum elevation above sea level approximately 5-6 meters below its current level at ca. 3.9kya, i.e., approximately 1900 BCE (Leroy *et al.,* 2013, 2019; cf. Kakroodi *et al.,* 2012: Fig. 12). Consequently, it is highly likely that there are an unknown number of sites currently inundated below the Caspian Sea. Second, due to the high rate of alluviation and colluviation in the region, an unknowable number of small sites likely lay buried under riverine and wind-blown sediment, especially along the main channel of the Gorgan Plain and in the loess belt located to the north and east of Gonbad-e Kavus (Asadi *et al.,* 2013; Karimi *et al.,* 2011; see also Leroy *et al.,* 2019). Third, the Gorgan Plain forms a contiguous geographic space with the plain of Mazandaran immediately to the west; twenty-four prehistoric sites have been documented just in the two easternmost counties of the province, bordering the Gorgan Plain (Mahfroozi 2003: Fig. 1; Piller 2012). Future analysis of the distribution of ancient settlements in the Gorgan Plain must take all three of these factors into account.

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چکیده

دشت گرگان در استان گلستان، یکی از غنی‌ترین مناطق باستان‌شناسی در ایران به‌شمار می‌رود. با توجه به اقلیم مساعد آن، دشت گرگان برای هزاران سال مکانی جذاب برای سکونت روستاییان کشاورز بوده است. در قرن نوزدهم و بیستم میلادی، این منطقه توجه سیاحان و باستان‌شناسان اروپایی را به خود جلب کرد که آنان مجذوب دیوار بزرگ گرگان، بقایای شهرهای قرون وسطایی و هم‌چنین صدها تپهٔ باستانی که موجود در دشت گرگان شدند. با این‌حال، باوجود بیش از یک‌صد سال بررسی باستان‌شناسی در دشت گرگان، هنوز اطلاعات بسیار کمی درمورد روندهای تاریخی سکونت قبل از عصر آهن وجود دارد. با استفاده از یکپارچگی دیجیتال پنج بررسی قبلاً منتشر شده از دشت گرگان و یک روش جدید بررسی از راه دور با استفاده از گوگل ارث، برای اولین‌بار امکان انجام یک توصیف بنیادی از الگوهای سکونت دیرینه‌تاریخی دشت گرگان فراهم شده است.

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