DRAFT / BORRADOR

María del Mar Castro García & Daniel J. Martín-Arroyo Sánchez (05 Jul 2024): Survey Techniques and Landscape Archaeology on the Banks of the Ancient *Lacus Ligustinus* (Southern Spain), Journal of Field Archaeology, DOI: 10.1080/00934690.2024.2372740

Survey Techniques and Landscape Archaeology on the Banks of the Ancient Lacus Ligustinus (Southern Spain).

1- María del Mar Castro García (corresponding author)

Departamento de Prehistoria y Arqueología.

Universidad de Granada, Phone number: 0034 627306119

C/Prof. Vicente Callao 7

18011, Granada.

ORCID ID: 0000-0002-9159-3096

2- Daniel J. Martín-Arroyo Sánchez

Departamento de Didáctica de las Ciencias Sociales

Universidad de Granada, Phone number: 0034 687985759

Ctra. Alfonso XIII s/n

52005, Melilla.

ORCID ID: 0000-0003-2790-941X

ABSTRACT

The use of complementary techniques in this paper contributes to a better understanding of the long-term evolution of the riparian landscape on the southern banks of the lacus Ligustinus (current Guadalquivir marshlands) through the knowledge of related human settlements. The techniques used included field-transect surveys, malacology, anthracology, radiocarbon dating, and magnetometry. With respect to the data, in-depth plowing at the archaeological site of Haza de Santa Catalina revealed vestiges of different time periods. Comprehensive data sets based on best archaeological practices were collected to explore holistic ecological perspectives and changes over time. Here, we focus specifically on the transition between the fourth and third millennia (Neolithic) and the first millennium B.C. (Iron Age – Early Roman period) in western

Andalusia. In addition, the theoretical frameworks related to the concepts of ‘riparia’ and ‘emptyscape’ are expanded with the knowledge gained in the archaeological fieldwork.

Keywords: riparia, emptyscape, longue durée, magnetometry, Neolithic, Iron Age, necropolis.

- Funding details.

This work has received funding from the European Union’s Horizon 2020 Research and Innovation Program under the Marie Skłodowska-Curie grant agreement No. 798529; the Aquivergia Project PID2021-125967NB-100; the Proyectos de Generación de Conocimiento 2021; and the Investigación No Orientada Tipo B del Ministerio de Ciencia e Innovación.

- Biographical note.

María del Mar Castro García is a specialist in Roman water management and the analysis of ancient settlements in water spaces. She obtained her PhD at the Université Laval (Quebec, Canada) and the University of Cádiz (Spain) in 2016. She gained several postdoctoral positions, including a Marie Skodolowska Curie Fellowship at the University of Siena and a regional Research of Excellence Contract at the University of Cádiz. Currently, she holds a postdoctoral position at the University of Granada (2023) under the Ramón y Cajal Research Programme of the Spanish Government. She specializes in the application of noninvasive archaeological prospecting techniques applied to the study of ancient landscapes in southern Spain.

Daniel J. Martín-Arroyo Sánchez is a specialist in the Roman economy. He gained his PhD in history (University of Cádiz, 2013) and a postdoctoral position within the European Project EPNet (University of Barcelona, 2014-2019). Recently, he was a visiting researcher at the Landscapes Archaeology and Remote Sensing Laboratory (LAP&T) (University of Siena, 2019-2021). Currently, he is an Assistant Professor of Didactics of Social Sciences (University of Granada, 2021-2024). His work as an archaeologist includes the direction of the field survey in Haza de Santa Catalina (2020). He investigated the case of Hasta Regia within the context of Roman colonization on the Iberian Peninsula. His expertise in the Roman economy is supported by different studies on amphorae and related epigraphy, as well as by the assessment of agricultural models based on GIS analyses. His recent research also addresses cultural heritage education.

ACKNOWLEDGMENTS

We thank Horizon 2020 of the European Commission for funding the LisguSTAR MSC Action. We are grateful to the owner of the plot at HSC, Rafael López Ibáñez, for facilitating access to the field site. We also thank the Unidad de Geodetección and its Director, Prof. Lázaro Lagóstena Barrios (Universidad de Cádiz), and our collaborators Esperanza Mata Almonte (Asociación

Profesional del Patrimonio Histórico-Arqueológico de Cádiz), Antonio López Rodríguez, Félix Ríos Jiménez (Sociedad Gaditana de Historia Natural) and Leticia Gómez Sánchez (Universidad de Cádiz). We thank the Departamento de Historia, Geografía y Filosofía (Universidad de Cádiz) for funding the English language editing of the manuscript.

INTRODUCTION

A complete understanding and therefore preservation of riparian spaces requires a perspective on the human-environment interactions within the *longue durée*. This primary thesis underpins the development of the LiguSTAR Project (Castro 2020), which in turn involves the concept of '*riparia*', new methodological approaches to the 'emptyscape', and specific study cases in the banks of the ancient *lacus Ligustinus* (western Andalusia).

The social concerns of sustainability and environmental preservation demand solutions from the scientific community. Some new policies can exploit our knowledge of the past. For instance, the United Nations posed the theme "Revive and restore degraded wetlands" for the 2023 World Wetlands Day. From the archaeological point of view, a better understanding of their evolution and relationship with humans can be offered. Within the Niche Construction paradigm and the 'Good Anthropocene' perspective, the reconstruction of ancient water systems is considered a convenient measure (Rosen, 2024). Wetlands can offer a particularly accurate record of human activity in surrounding landscapes. However, the evidence can be spread through the territory and masked for recent transformations.

Our theoretical framework links the *lacus Ligustinus* to the '*riparia*'. This concept involves the study of relationships between human populations and the environment, considering banks and wetlands (Hermon 2014, 5-7). Framing the concept in *longue durée*, researchers address comparative environmental history (Hermon 2021) and social representations from Antiquity to modern times (Hermon 2022). Furthermore, these works address the research from the perspective of the watershed scale, which invites us to consider the entire Guadalquivir Valley, particularly for erosive and sedimentary infilling processes. Framing the concept of the '*riparia*' in a more restricted historical period, Latin land surveyors provides valuable insights on water management practices (Hermon 2020). From this theoretical framework, studies on different riparian formations have been carried out by discussing specific Baetican cases (Castro, Bastos, and Bocanegra 2014; Lagóstena 2015; Lagóstena, Castro, Bastos 2015).

Regarding the survey methodology, LiguSTAR was used to explore the concepts of 'emptyscape' and 'archaeological *continuum*' (Campana 2018). The ensuing approach increased the attention given to the space between archaeological sites, where scattered pieces of evidence may be essential for interpreting ancient settlement patterns. Furthermore, there is another type of 'emptyscape' in our study zone: Ancient marshlands. Traditional field surveys have been avoided in these wide areas with very scarce archaeological surface records. Within the LiguSTAR project, these areas have been explored near several Roman sites.

Further investigation could be afforded with the help of a large-scale geophysical survey, as carried out by the emptyscapes initiative of the University of Siena for the Grosseto-Roselle valley (South Tuscany, Italy) (Saito 2023). A bibliometric analysis of the use of GPR and geophysical methods offers an overview of the increasing number of works within this emerging subdiscipline, though with challenges involving aspects such as the valorization of the resulting data as primary sources (Lagóstena and Aragón, 2023). The combination of non-invasive methods (geomagnetic survey, GPR, electric tomography and LiDAR) has offered interesting results for the fortified settlement of Cerro de la Breña (Talaván, Cáceres, Spain) (Mayoral et al. 2023). From this methodological approach, a survey on the Iron Age necropolis of El Toro (Alcubillas, Ciudad Real, Spain) (Catalán et al. 2022) offers possible parallelisms for Haza de Santa Catalina (HSC), in the LiguSTAR's study zone. In addition, explorations of other sites via GPR are being undertaken near our study area (Lagóstena 2021; Lagóstena et al. 2021).

LACUS LIGUSTINUS

The geographical framework of our study is the ancient marshlands of the lower Guadalquivir valley. Literary sources, archaeological evidence, and paleoenvironmental records provide information on this framework. Literary sources address different aspects of this region according to the changing interests and perceptions of ancient Mediterranean societies (Lagóstena 2014). Here, the *lacus Ligustinus* appears between the coast and the river, related to waterways and shallows that offer navigation opportunities and risks. In this realm, interpretation requires a thorough exegesis involving the understanding of partial descriptions of an evolving landscape given by different authors with their original sources of information (Ferrer 2012).

As a part of the paleoenvironmental record, sedimentary infilling provides information on catastrophic events, the evolution of the *lacus*, and the inland exploitation of natural resources. Extreme wave events could have affected ancient settlements and/or archaeological evidence. Micropaleontological analysis of sediments from a core (Guerra et al. 2020, 11) extracted 17 kilometers to the north of Cortijo de Évora points to the existence of a lagoon with marine connections during the Roman period. Marine connections were progressively limited until fresh waters were predominant during the 4th-5th centuries AD. Another core, 13.5 kilometers to the northwest of Cortijo de Évora, offers information about three different phases (González-Regalado et al. 2020). The first phase (900-218 BC) was defined by the alternation of lagoonal silty sediments and marsh deposits, the latter with slight pollution from mining activities. The second phase (218-60 BC) was a tsunamigenic period characterized by the erosion of previous dune systems. The third phase (60 BC-present day) involves a regressive sequence with the final implantation of the present-day dune systems and evidence of increased metal pollution from Roman mining. On the other hand, organic remains from archaeological excavations have been examined at several sites (García-Viñas and Bernáldez 2018). Concerning the possibility of comparison with the HSC records, a limited scope is given by the chronological and geographical framework of this work, which focuses on the Iron Age and the eastern side of the *Ligustinus*.

EBORA

Different cities named *Ebora* are on the Iberian Peninsula (Carriazo 1970, 28-29). In the context of the Atlantic coast near the ancient city of *Gades*, *Ebora* is mentioned both as a *polis* (Strabo, 3.1.9) and as a *castellum* (Mela, 3.1.4) in written sources from Roman times. Traditional research has identified *Ebora* with superficial remains from Cortijo de Évora, consisting basically of sherds. Despite the interest following the discovery of an ancient treasure (dated between the 7th and the 2nd century BC), only a restricted excavation was implemented in the 1950s. Later, the investigation recorded other aspects of the site, but in-depth research has not been carried out (see bibliography in Parodi et al. 2019, 251-256; Castro 2020, 2-3). Recent research has focused on interpreting the treasure regarding its eastern religious symbols (Gómez 2018) and its possible relationship with a Turdetanian sanctuary in Cortijo de Évora (Martín 2018-2019).

From the literary sources, descriptions of the connections between the *lacus Ligustinus* and the sea are particularly interesting for determining the strategic relevance of *Ebora*, both as a military and a trade port. Navigability in the zone was related to items such as the *Monumentum Caepionis* and the sanctuary of *Lux Dubia* (Fig. 1), but special attention must be given to the process of enclosing the southern mouth of the *lacus* because of the formation of the tombolo of La Algaida between the 1st century BC and the 2nd century AD (Rodríguez et al. 2016, 115; Castillo and Iguácel 2021, 124). This tombolo was presumably well consolidated when an extreme wave event occurred between the years 100 and 300 AD, which failed to breach it by means of inlets (Rodríguez et al. 2022, 141).

Analyses of archaeological data provide insights into physical and human aspects of *Ligustinus* as a geographical framework for this research. Regarding the surroundings of *Ebora*, the salt-fish factory beside the sanctuary of *Lux Dubia* has been interpreted as evidence of the navigability of Caño Cardales during the 1st century AD (Menanteau and Vanney 2011, 19). As an ancient waterway, Caño Cardales can be considered the main connector between *Ebora* and the river. Furthermore, the exploitation of banks on the southern side of *Ligustinus* has been explored at two different scales: the urban network and its terrestrial interconnections (Lagóstena 2016) and the *territorium* of *Hasta Regia* (Ruiz et al. 2019), which includes the hinterland of *Ebora* (Martín-Arroyo 2018, 267-268). Here, *villae* and amphorae workshops can be studied regarding the network of piers that configures trade routes through the *Ligustinus.*

Ebora was located at the northeastern extreme of an ancient peninsula bordered by two branches of the *lacus Ligustinus* (Fig. 1). Within the LiguSTAR Project, the surveyed area encompassed approximately three square kilometers of this mainland and a narrow buffer of former marshes. This included the sites of Évora A and B, which were probably the result of the displacement of the first center of activity toward the second at some point at the beginning of Roman imperial time (Castro 2020). In the southwestern part of the surveyed area, the 100-meter-wide transects allowed us to record some archaeological evidence, although at the time, it was not possible to establish any chronological context. Later, a sherd of black gloss pottery was found during a new visit to HSC (Fig. 1). A more exhaustive survey (25 meter-wide transects) offered few eroded sherds of black gloss and red-painted pottery. A year later, an 80 cm deep plowing (deeper than traditional plowing) brought to light many new and more diverse remains. After informing the provincial authorities (Delegación Provincial de Cultura de Cádiz), a formal archaeological project was carried out, the main results of which are detailed in this paper.

OBJECTIVES

Our objective was to explore different epistemological approaches for landscape archaeology from a specific case study, with particular regard to inhabitation and settlement patterns in riparian environments. According to this objective, a secondary aim was to offer solutions for strategic fieldwork design in similar projects, including the selection of study zones and samples, as well as the management of resources and different techniques for obtaining comprehensive data sets. Another secondary aim was to assess the potential of different field archaeology methods, their limits and their positive results according to experiences in HSC. The last aim was to interpret the evidence from HSC within the theoretical frameworks about the related environmental contexts and settlement patterns. Moreover, the distributions of surface materials and their relationships with missing or partially preserved structures were investigated. Then, we aimed to identify chronologies and original functionalities, including comparisons with other archaeological sites, mainly from the surrounding region.

METHODOLOGY

The archaeological record at HSC (Fig. 2) consisted of field surveys performed on foot, including the collection of samples for analyses of paleobotany, ^{14}C, malacology, and metals. Furthermore, an archaeological trench, drone surveys, and magnetometry were carried out.

A systematic field survey was performed with the help of three sets of transects that were 50, 25 and 10 meters wide. After a previous visual inspection, distances between the transects were established according to the perceived density of the vestiges and the resources (time and labor) available for implementing the survey project. The orientations of the transects were aligned with the topography (contour lines). Survey resources consisted of two archaeologists and a collaborator who were organized in two groups with their respective GPSs to survey even and odd transects. The nature of the positioned materials was recorded in notebooks. Every diagnostic sherd (rims, bases, and handles) was collected in a separate bag with a label indicating the used GPS and the recorded position. These bags were stored in separate common bags every survey day. This procedure enabled efficient use of time during the field survey and proper organization of scattered pieces of information.

The entire plot of land was surveyed (Fig. 2), although only the eastern half had been plowed. In this respect, comparisons could be made according to the density of the findings on both sides of the plowed area, particularly in the more intensively surveyed area. The zone that was surveyed with 10-meter-wide transects was defined based on three factors: former findings, new findings, and topography. Findings from the previous survey (25-meter-wide transects) indicated a presumably unearthed burial area to the west of the plowed zone that required a more detailed survey. Here, an archaeological trench (Fig. 2) was used to explore the stratigraphy in the zone unaffected by recent plowing. The high degree of compaction of the substrate enabled only the manual digging to 50 centimeters depth to be performed. This trench provided no other relevant information. Preliminary visits to the plot determined that artifacts were densely distributed between the former area and the next land elevation to the east (see lines of elevation in Fig. 2). From here to the eastern extreme of the plot, the presence of materials was strongly affected by a deep trough, although the density of the materials was recorded in the elevated terrain on the opposite side. However, this narrow fringe was of little interest because the remains have not been dated or identified to ancient activities or structures. Here, the limit of the land plot coincided with the boundary of the official protection area of Cortijo de Évora.

The 80-cm-deep plowing removed large blocks of compacted soil, which affected the mobility of the surveyors, the visibility of the remains, and the sampling (Fig. 3). Every piece of evidence was georeferenced, and the most relevant items were collected (diagnostic sherds, stone tools, metals, complete malacological remains, etc.). Other vestiges, such as building stones or earth displaying traces of rubefaction due to exposure to fire, were also recorded via both GPS and photography. However, for a more detailed view of the terrain, two sets of axial photographs were obtained by a drone (Mavic 2 DJI) flying at 70- and 7-meter heights (Fig. 2). These photographs could enable the study of different natural and archaeological substrates by identifying them through their colors and analyzing their spatial distribution as they were brought to light through plowing. This research requires future efforts in the computational data management of large sets of photographs and interdisciplinary identification of the substrates.

After finishing the superficial record, sample collection for analyses was facilitated by the concentration of evidence at very restricted points, defined by the presence of ash that was frequently compacted within blocks of earth (Fig. 3).

A total of 15 samples of ash and charcoal were collected for paleobotanical analysis (Tables 1 and 2), considering well-preserved blocks of earth with abundant remains. In this way, they were directly collected from the ground, avoiding intrusive materials. Twelve samples were taken from the burial zone dated to pre/early Roman times, over the alignment of vestiges that were later identified by magnetometry. One sample (A-007) was associated with an undefined settlement in the center of the intensively surveyed area, as explained in the Results section of this paper. Three other samples (E-175, E-176, and E-179) were extracted from the Neolithic site to the east. Sample E-175, with a volume of 8.100 g/5 L of sediment, provided no suitable material for analysis.

The collected samples were studied by the Portuguese laboratory of ERA Arqueologia, S.A. They used flotation to extract charcoal and seeds using a bucket and a 0.25 mm grid to recover larger- and smaller-sized samples, respectively. Charcoals larger than 2 mm in diameter were collected. Twenty samples for practically every context were randomly selected, for a total of 252 fragments. Three sections (transverse, longitudinal tangential, and longitudinal radial) of these samples were examined via incident light microscopy (100x and 200x) for identification. The taxonomic identification of charcoal was conducted with the help of an anatomic atlas of trees (Schweingruber 1990) and a reference collection of modern coals at the ICArEHB – University of Algarve.

During the collection of ash and charcoal, 17 samples were collected for ^{14}C analysis. Two main criteria were followed to ensure their validity. Samples were collected from well-preserved contexts, such as blocks of compacted earth, avoiding intrusive materials. The largest charcoals available were selected, and clay was preserved when it surrounded the sample. Sterilized materials were used to pick up and transport the samples. Recently, two samples (D598 and D637) were selected because of their position over two of the presumably tumular structures that were attested by magnetometry (Fig. 2). Chemical pretreatment was carried out by the iCONa laboratory, the laboratory for the analysis of isotopic relationships, at the Department of Environmental, Biological and Pharmaceutical Sciences of the University of Campania 'Luigi Vanvitelli'. The radiocarbon contents were measured with accelerator mass spectrometry (AMS).

Malacology samples were collected during both the field-transect survey and, particularly, within a more detailed examination of the Neolithic area (Fig. 2). The field-transect survey provided 99 samples of bones and shells, which were considered sufficiently preserved to be satisfactorily examined by specialists. The Neolithic area was characterized by concentrations of ash associated with sherds and stone tools. Malacological remains were present in different proportions, sometimes in quite large numbers (Fig. 3). During the field-transect survey, all the concentration areas were marked aboveground so that they could be revisited for further investigation.

Twelve one-kilogram samples of substrate were collected from their respective concentrations, selecting those with higher quantities of visible remains. The malacology was extracted by using flotation and a 0.5 mm grid. The remains were clustered into different groups according to their homogeneity and identified species. Vestiges of probable intrusive species from places other than the archaeological substrates were identified using a binocular loupe and removed. They consisted of the remains of three species of terrestrial snails: *Otala lactea* (Müller, 1774), *Xerotricha apicina* (Lamarck, 1822), and *Theba pisana* (Müller, 1774). Similarly, lacking a relationship with the archaeological substrate, the presence of *Pecten maximus* (fossil) was confirmed. Evidence of eight other species was found, which will be discussed in the Results section.

After sampling, a more exhaustive visual examination of the concentrations of ash was carried out by breaking the blocks of earth and digging the substrate. The objective was to collect stone tools and sherds, including both diagnostic and nondiagnostic fragments, to reconstruct pottery forms. The possibility of total or partial reconstruction of pottery shapes was given by considering the ash concentrations as probable stratigraphic units, in which large or complementary fragments could have been preserved with minimal alteration after plowing. The concentrations were graphically recorded using archaeological meter scales. A more exhaustive recording in this respect was carried out through the drone survey. To obtain an indicative sample, the volumes of two concentrations of ash in the Neolithic area were measured: 1) 3.300 g/35 L from a 0.5 × 2 m concentration and 2) 2.300 g/25 L from a 0.6 × 1.1 m concentration.

The preliminary identification of a burial zone dating from pre/early Roman times was linked to the detection of other concentrations of ash that were smaller than the Neolithic concentrations and frequently associated with sherds and small fragments of bones. They were also marked aboveground for further investigation to recover funerary offerings and sherds of complete pieces of pottery. Here, the remains of metallic objects were recurrently attested during the field-transect survey. In this respect, a more exhaustive visual examination of these ash concentrations was preceded by inspection with a metal detector (Fisher M-scope 1225-X model) (Fig. 2). The use of a metal detector yielded mixed results. Sometimes the signals did not correspond with the finding of metallic remains, or it was impossible to find them. Despite these anomalies, this one-day survey with a metal detector obtained 52 of the 71 inventoried metallic remains in HSC.

Magnetometry can be used to successfully find materials with abundant magnetized remnants that were caused by fire. The magnetometer generates unique images (i.e., magnetograms) from vestiges located at depths up to 1.5 m. In HSC, the main objective was to record structures from the necropolis. Beyond the disruptions caused by plowing at different depths, the expected results would reveal features/structures from depths ranging from 20-80 to 150 cm. The MX V3 model (fluxgate gradiometer FGM650/3) of Sensys is a modular multichannel magnetometer with up to 16 fluxgate gradiometers on a 3.85-m wide trailer. It provides images with a resolution of <0.2 nT and a standard measurement range of ±10 μT. Geopositioning was carried out with a performance and precision GPS/GNSS system for real-time kinematics (RTK), Stonex S10. The equipment used as the base was a Stonex S10 and Rover S10A, with a precision of ±1 cm. Data postprocessing was accomplished with DLMGPS and Magneto software. The specialized equipment belongs to the Unit of Geodetection, Analysis and Georeferencing of the University of Cádiz.

Two magnetograms were obtained from three campaigns (one of them failed). They covered 22.084 m^2 within the zone surveyed with 10-meter-wide transects, which was an approximately 300 × 100 m area (Fig. 2). The first campaign was conducted in October 2020. The modular trailer, with 16 gradiometers (25 cm from each other) and a configuration of 20 Hz, was pushed by two operators. The orientation of the 385 cm wide transects was southwest–northeast according to the direction of plowing. The presence of parked farm machinery at the higher point in the western region made it impossible to complete the survey in this area. The resulting magnetogram covered 12.069 m^2 in the western part of the more intensively surveyed area. In the second campaign (2021), the magnetometer was pulled by a car. Due to the survey speed and the irregularity of the terrain, we were not able to obtain satisfactory data. During the third campaign, a survey with 120-centimeter transects (5 gradiometers spaced 30 cm from each other) was conducted. The northwest–southeast direction of the transects corresponded with more recent and less aggressive plowing that allowed for better coverage of the terrain. There were fewer observed archaeological features in the eastern 10.015 m^2 area than in the former area, but the magnetogram more faithfully imaged minor features related to the concentrations of ash on the land surface.

RESULTS

The first set of outcomes included the data from the surface records and the collected samples. Afterward, more detailed descriptions and interpretations of the evidence from the Neolithic and pre/early Roman phases of the site are provided.

Overall record

Fig. 4 shows 2519 points representing the locations of the materials. Kernel analysis involves a density probability function that considers two dimensions. Departing from every nucleus, with X and Y coordinates, a smoothed approximation of the centrifugal distribution is calculated for the point data set (Conolly and Lake 2009, p. 234). In Fig. 4, this geodesic density was calculated according to default parameters established by ArcGIS (v. 10.4.1). The indicated number of points (N) was given according to the square meter, which was the size of the pixels in the resulting raster layer of ArcGIS.

Kernel density analysis revealed the main area where findings from the pre/early Roman phase were concentrated. The secondary concentrations of points included the surroundings of the abovementioned area, the Neolithic area and the northeastern site of the plot, among other minor gatherings of materials. In 2020, a preliminary report was sent to the Delegación Territorial de Cultura y Patrimonio Histórico de Cádiz to protect three delimited areas (Fig. 8): polygon A-1 (1.2 ha.), A-2 (0.6 ha.), and A-3 (1.3 ha.). Polygons of protection indicated areas where the most relevant pieces of evidence were recorded, including those where underground vestiges were attested or could remain untouched immediately below the 80-centimeter-deep plowed level (20 centimeter-deep on the western side of Polygon A-1). The remaining concentrations were related to two main factors: hydrotopography and contamination. A hydrotopographical effect could be assumed on both sides of Polygon A-1. It was delimited within a gentle slope to the southeast, with numerous materials displaced in this direction. Two minor troughs, with their respective concentrations of materials, descend to the northwest of the mentioned polygon, while higher densities of materials were recorded along the main trough from the eastern side to the northern limit of the plot. These troughs converge at a central drainage ditch in the incoming branch of the ancient marshland. Along the central section of the northern border of the plot, contamination from intensive cultivation of the neighboring vineyard was observed (from manure and added earth containing abundant waste). This phenomenon was also observed at other sites in the region

(Castro 2020, 14). In this sense, surface records of the neighboring sites of Caserón de Evorilla (0.5 kilometers to the east of HSC) and Cabeza Gorda (0.7 kilometers to the north) were practically imperceptible. Adding earth to improve agricultural soils in lowlands usually involves few artifacts but can also mask ancient vestiges and the original topography, as observed between Évora A and Évora B (Fig. 1) during the fieldwork of the LiguSTAR Project. Paths along the southern and western borders of the plot also exhibited contamination, as they were repaired with contemporary debris (Fig. 8).

To explore more holistically diachronic changes within these landscapes, we now turn to specific material indicators, notably ceramic analyses. Among the collected 1746 pieces of evidence, there are 11 fragments of glass, 19 fragments of adobe, and 71 fragments of metal, as well as 40 lithic elements and 99 animal remains (shells and bones). Most of the 1506 recorded sherds consisted of diagnostic elements, but a certain number of other less relevant pieces were retained due to the possibility of a more complete reconstruction of some pots from well-defined contexts (concentrations of ashes). Further typological information about the recorded sherds will be presented in this paper with respect to the Neolithic and pre/early Roman areas.

Neolithic area

Within Polygon A-2, the initial evidence consisted of concentrations of ash containing different proportions of materials (Figs. 3 and 5). Currently, no radiocarbon dating has been performed for this area, but malacological samples are available for future research in this respect. A preliminary analysis of the pottery records points to the transition between the fourth and third millennia B.C. The record of Los Castillejos (Montefrío, Granada) (Arribas and Molina 1979) has been used as a reference study for HSC, as has the typological series from different southern Iberian sites. Particularly relevant are two sites with published stratigraphic records, namely, La Esparragosa (Chiclana de la Frontera) (Vijande et al. 2019) and SET-Parralejos (Vejer de la Frontera) (Cantillo 2014; Villalpando and Montañés 2009; Villalpando and Montañés 2016), both of which are in the province of Cádiz.

In HSC, pottery fired in a reducing atmosphere is predominant with respect to those from oxidative atmospheres, but evidences of regular and irregular firing are similar in quantity. The coloration of the sherds is quite homogeneous and dominated by orange, brownish and beige tones. In contrast, some sherds have a darker coloration, with black or grayish tones. In most cases, the corrective additives in clays are abundant (69 sherds) and large (69 sherds). Middle (19) or scarce quantities (37 sherds) have been observed in a certain number of cases, as have the medium (20) and small sizes (41 sherds) of the corrective additives. This pottery record from HSC consists of 896 fragments: 761 nondiagnostic sherds, 111 diagnostic sherds (rims and bases), and 24 decorated sherds (including those with prehension elements). The typologies of cooking pots and bowls are predominant, as usual in late Neolithic contexts. Cooking pots with slightly incurved rims stand out in HSC, as do those with spherical or hemispherical bowls. Furthermore, S-shaped vessels and various types of platters were recorded. The prehension elements consisted of two mamelons and two handles. There are fragments with incised and printed decorations, as well as perforated sherds and others with traces of paint.

A total of 21 flint tools and fragments were recorded, including evidence of every phase of lithic reduction. According to the Sistema Lógico Analítico (SLA) (Carbonell, Guilbaud, and Mora 1983), the records in HSC include cores (BN1G), flakes (BP; including a wide variety of results), retouched artifacts (BN2G), and splinters (OTR; other remains of lithic reduction). For further research, some reference assemblages were obtained from Cantarranas (El Puerto de Santa María) and El Trobal (Jerez de la Frontera) (Ramos et al. 1991-1992).

Furthermore, 7 polished lithic tools and 5 other fragments were recorded, in addition to a large carved block of stone. Polished artifacts on the Atlantic coast of the province of Cádiz have been common since the late fifth millennium B.C. Here, they have been related to increases in both natural resource exploitation and new economic practices in Neolithic communities (Domínguez-Bella and Pérez 2008). Details on the sources, manufacture, utility, and depositional processes of the polished stone tools can be found in some specialized studies for the Neolithic and Copper Age in Southern Iberia (Domínguez-Bella et al. 2010).

As our work is keenly interested in scalable data sets and, notably, zones apparently void of cultural markers in the archaeological record, we now turn to an exploration of our emptyscape framing. A previous survey in HSC (Parodi et al. 2019, Fig. 4) and our own archaeological prospecting before deep plowing did not provide information regarding this phase. Within the municipality of Sanlúcar de Barrameda (170 km^2), no other Neolithic site has been detected. Surface records (site of Bustos) or isolated findings (Alventus-El Nono) (Fig. 6) are the usual type of evidence for open-air settlements, as traditional research has focused on caves. An exception can be found in El Cabezo de Lebrija (Fig. 6). Few sites are known in the neighboring region, in contrast with the number (at least 55) recorded in the southwestern region of the province of Cádiz (Ramos et al. 2017; Fig. 4). In this respect, the lack of research can be added to the effects of the transformation of the territory, including sea level rise, a receding shoreline, aeolian dune formation, and successive tsunamis that have eroded the archaeological surface record (Rodríguez-Ramírez et al. 2014, 134-135). The case of Rajaldabas, a nearby Bronze Age site, is notable because it was located at a low-altitude point that was later affected by sea level rise and the formation of marshes (Parodi et al. 2019, 62) and/or by a tsunamic event *ca*. cal yr 1150 BC (Rodríguez et al. 2022, 139). This case highlights the importance of paying more attention to the apparent 'emptyscape' beyond the recorded sites.

Regarding the riparian character of the site, the Neolithic settlement at HSC was located approximately 30.5 meters above the current sea level (Fig. 5). The surrounding areas within one kilometer have higher elevations (49.5, 43.5, and 40.5 m.a.s.l.). However, the site is located between two alluvial formations, which can mask longer penetrations of ancient marshes or ways of accessing riparian environments. In fact, the current elevation of the incoming branch of the ancient marsh to the northwest is barely 2.5 m.a.s.l., involving steep slopes at some points that could have been difficult to pass. Even if shellfish could have been collected far from the site, most of the HSC evidence could be associated with the surrounding ancient marshland, providing data for paleoenvironmental reconstruction. Seven species have been identified in the Neolithic phase at HSC. In order of abundance, the following four species were noted, all of which are edible: *Crassostrea sp*. (a genus of true oysters (family Ostreidae) that generally live in the intertidal zone), *Solen marginatus* (Pulteney, 1799; common name, the 'grooved razor shell'), *Eastonia rugosa* (Helbling, 1779; bivalve), *and Bolinus brandaris* (Linnaeus, 1758; the purple dye murex (or spiny dye-murex) is a species of medium-sized, predatory sea snail living in sandy-muddy or detrital seabeds near the marine wavebreak zone). The other identified species were as follows*:* *Parvicardium exiguum* (Gmelin, 1791; bivalve), *Cerithium vulgatum* (Bruguière, 1792; sea snail), and *Ruditapes decussatus* (Linnaeus, 1758; edible bivalve).

The anthracological evidence offered by E-176 and E-179 was scarce (Fig. 2 and Table 2). However, the presence of *Quercus* sp. pointed to a 'Dehesa-type' landscape (open savannah-like woodlands), which is associated with the Copper Age in the region and linked to intense human activity. According to the record of the Middle Neolithic A period of the Dehesilla Cave (ca. 4800-4500 cal BC) (Fig. 6), a turning point can be detected related to a strong decrease in forest cover and the creation of thermophilic forests likely caused by extensive agricultural systems (García-Rivero et al. 2022, 552). On the southeastern shores of the bay, the presence of Cardial wares during the Early and Middle Neolithic was related to human groups who utilized agricultural practices; moreover, their absence on the northwestern shores was linked to pastoralism. The different natures of the soils on both sides of the ancient bay support this hypothesis. Finally, changes in the composition of the archaeological records in southern Iberia during the second half of the fourth millennium B.C. were related to the influence of the Maghrebi Neolithic (Escacena 2014, 88-90).

The exploitation of coastal resources and open-air settlements have been insufficiently studied due to the conditions mentioned above in this epoch's surface record. In turn, this is highly inconvenient for reaching a satisfactory understanding of the expansion of agricultural practices and the associated landscape transformation as a paradigm of the Neolithic Age. Data from resource consumption and topographical emplacement at HSC are interesting for the elaboration of predictive models to detect new sites and elaborate explanatory hypotheses on the spatial distribution of the evidence.

Pre/early Roman area

The vestiges within Polygon A-1 included evidence of a necropolis dating from the 8th to the 2nd centuries BC and a postancient site with an undetermined chronology and functionality. However, both phases require further investigation to determine their chronologies. Particular attention must be given to the eastern part of the polygon, where traces of both phases overlap.

With respect to the pre/early Roman area, the collected sherds included a variety of shapes of different types of objects (plates, bowls, urns, cooking pots, amphorae, etc.). A relevant portion of them fit the dates indicated by the ^{14}C analyses: 212 (±50) (for D637; related to Group 3 in Fig.

7) and 138 (±48) BC (for D598; Group 5). However, the prolonged craft tradition of the Turdetanian painted pottery (Ferrer and García 2008, 202) and the Phoenician-Punic amphorae allows us to provisionally expand the proposed chronological framework of the site toward the 8th century BC. Moreover, a few finds can be dated back to the Early Iron Age (Tartessian period, 8th-mid-6th centuries BC). These include hand-thrown sherds with typological parallels in the Mesas de Asta necropolis (Barrionuevo and Torres 2021). Tumular structures, as stated below, can be generally dated within this enlarged chronological framework. Other elements related to burial are the concentrations of ash, with or without fragmented bones, sherds or traces of earth that was rubefacted due to fire exposure. Their diversity can be related to graves as well as to associated rituals and structures, such as *silicernia* and *ustrina*. Other relevant artifacts consisted of a group of five astragalus bones, three spindle whorls, a glass bead and a spearhead.

The anthracological record of this phase consists of 225 coals, with sample D-598 dating back to 138 (±48) BC (Table 2 and Fig. 2). More than two-thirds were composed of the families *Ericaceae* (including *Arbutus unedo*, commonly referred to as 'strawberry tree'; 4%) and *Oleaceae* (olives and others; 45%), as well as the *genus Pinus* (pines; 23%). Considering the representativeness of the record in terms of the environmental context, the selection of woods and plants for a specific use in cremation and rites must be considered. However, the three mentioned groups of trees provide edible fruits, which can be interpreted as remnants of forestry practices. This record from HSC can be contrasted with those from the Doña Blanca (López and López 2003) and Pocito Chico (López, López, and Martín 2001, 55) sites. According to records from Pocito Chico, at the regional scale, Mediterranean coastal pine forests on fixed dunes were dated to the Late Bronze Age and the beginning of the Iron Age. On the other hand, southern Spain is a hot spot of oleaster genetic diversity and traditional olive varieties that are particularly interesting for understanding their domestication and diversification processes (Díez et al. 2015, 443). Based on the palynological record, large-scale olive horticulture was detected on the Iberian Peninsula as early as the mid/late 3rd millennium BP (Langgut et al. 2019). The initial coastal cultivation was related to the influence of the Phoenicians and Greeks, followed by an inland spread in Roman times (Voropaeva and Stika 2018, 879-880). The economic importance of wild and/or domesticated olive groves in the hinterland of *Ebora* should not be disregarded, nor should viticulture, which was attested to in regional contexts dating from the 5th to the 3rd centuries BC (Martín-Arroyo 2018, 258). By Roman times, these agricultural practices could have generated a cultural landscape in the surroundings of *Ebora*, including places such as the sacred woods (*lucus*) *Oleastrum* (Mela, III, 1, 4).

To describe the magnetometry results (Fig. 7), the anomalies were divided into sets. To further understand this record, consulting the classification scheme of magnetic anomalies by G. Tol et al. (2021, Table 3) is recommended. At HSC, the anomalies can be divided into ten sets based on their classification: seven groups (1-7), two alignments (8-9), and one zone of dispersion (10). Groups 1 to 3 are sets of single anomalies, partially (1) or totally (2-3) recorded by magnetometry, with different probabilities of disruption by the different types of plows. Groups 4 and 5 are configured with well-defined circumferential shapes approximately ten meters in diameter. Group 4 is basically composed of differentiated single anomalies, while within Group 5, a single linear anomaly is the main element. Although they also have circumferential shapes, groups 6 and 7 are located at a significant spatial distance from the aforementioned sets. They also differ in size, with diameters of approximately eight and five meters, respectively. Group 6 basically consists of one linear anomaly and one single anomaly. The linear anomaly seems to be composed of single anomalies with remarkable dipole characteristics. Partially surrounded by the linear anomaly, the second anomaly is a well-defined circular single anomaly with a negative amplitude. This type of anomaly is usually related to pits or postholes (Tol et al. 2021, Table 3). Group 7 consisted of a linear anomaly with a semi-circumferential shape. Groups 8 and 9 are alignments with the same overall orientation (SW–NE) observed in the remaining aforementioned evidence. Group 8 fits the distribution of concentrations of ash, as observed for Groups 3 to 7. However, this is not the same case for Group 9. In this respect, Groups 9 and 10 could not be related to the necropolis. On the other hand, anthracological samples and ^{14}C dates (Fig. 7) could differ in their relationships with the observed anomalies. They could be related to preserved underground structures or disrupted structures or to coetaneous structures or overlapped structures with different chronological contexts.

Several factors must be considered in the interpretation of these results. First, the necropolis can be linked to the city of *Ebora* in the period when it was located at Évora A. The emplacement of this necropolis could be related to the connection of the Cañada de Burujena to the ancient city (Fig. 1); furthermore, it was not in a very prominent position, with a relatively low altitude and visibility from its surroundings. Several burial areas of the city could have coexisted, as suggested for other sites, such as Cerro de los Infantes (Pachón and Carrasco 2005, 21) or Mesas de Asta (Barrionuevo and Torres 2021). Even when areas other than HSC could have been preferred, HSC seemed to have been in use long before the Roman imperial times. Long periods of activity and different typologies of graves, including *tumuli*, have been recorded in necropolises such as El Villar de Archivel (mainly dating from the 4th to the 1st centuries BC; Brotóns 2008). Furthermore, *tumuli* can contain diverse archaeological units (graves, *ustrina*, *silicernia* or ritual deposits), as proposed for *tumulus* L127 (3rd century BC) at La Albufereta (García 2021). According to the distribution of the concentrations of ash and magnetic anomalies at HSC, evidence of clustered (sets 1 to 7) or simply juxtaposed (8 and 9) graves and/or ritual vestiges can be distinguished. The circumferential shapes suggested that at least some of the aforementioned groups (4 to 7) can be interpreted as *tumuli*.

The hypothetical *tumuli* were approximately located on the water parting but at different altitudes (between 22 and 24 m.a.s.l.). Consequently, the preservation and recording of each one could be considered separately. The building structure of Túmulo 1 (Córdoba and Ruiz 2000) could be used to interpret the evidence at HSC. This *tumulus*, dating from the 8th century BC, was completely excavated. It was located in the necropolis of Las Cumbres, related to the site of Castillo de Doña Blanca (8th to 3rd centuries BC). This site was only 21 km southeast of Cortijo de Évora, and its location was related to the ancient riparian landscape of the Bay of Cádiz. Although it was probably larger (20 m in diameter) than those from HSC, this *tumulus* could be regarded as the most similar and well-recorded parallel, mainly due to its regional and cultural framework. Overall syntheses of the *tumuli* in the southern (Ruiz, Rísquez, and Molinos 2011) and northeastern (López 2008) Iberian Peninsula can be consulted in this respect. Túmulo 1 was a structure with an average height of 1.5 meters, reaching a height of 1.8 meters in its central part. At its lower level, a central *ustrinum* was surrounded by different kinds of cremation graves, which were unequally distributed and clustered. The large single magnetic anomalies in groups 1 to 3 could be related to these types of items, perhaps involving little or no preservation of the highest levels of the *tumuli*, or they could simply be related to other kinds of graves. The first set of Túmulo 1 graves was consecutively covered with red clay. Other graves were excavated, and rituals were carried out on the resulting red clay platform. Single anomalies in Group 4 could be related to graves and vestiges of rituals that would have been arranged with respect to a similar circular platform. In fact, the concentrations of ash were more abundant in groups 3 and 4; however, they were less abundance in groups 1 and 2, which were not affected by in-depth plowing. After building a levelled platform in Túmulo 1, a horseshoe-shaped wall was constructed according to the slope of the terrain that embraced a last frustoconical layer of earth and small stones. This type of wall could be related to the linear anomaly in groups 5 and 7. In the latter case, a smaller *tumulus* size would have been advantageous for better preservation, even in a higher terrain. The evidence from Group 6 could be related to a burial chamber. In fact, at Las Cumbres, circular masonry chambers have been related to some *tumuli*.

Post-ancient area

In the postancient area (Fig. 8), a concentration of tile fragments has been associated with stones found in a narrow area, which can be interpreted as evidence of a rural building. Other materials, particularly sherds, have not been dated. Here, the presence of glasses and glazed ceramics is particularly high (6 fragments) with respect to the remaining plot. In fact, among the vestiges of this type (glasses, glazed ceramics, and modern materials), only 21 fragments were not directly associated with the borders of the plot. The anthracological sample A-007 (Table 2 and Fig. 8) supports this. The lack of remains of the *genus Pinus* (pines) or the family *Ericaceae* and the presence of the *genus Quercus* (oaks) attested to a different landscape. In this sample, oaks comprised three-fifths of the evidence related to trees in HSC, contrasting with the overall predominance of the *genus Olea* (olives and others) in the 11 samples to the west of A-007. According to these records, the related anomalies in the magnetogram (Fig. 8) could be considered postancient remains, such as vestiges of pits and/or other structures, as well as single artifacts. However, there were no signals of orthogonal structures that could be more precisely related to a rural building. In this respect, the postancient archaeological layer could have been completely removed from the stratigraphy by plowing. The circular shape of some groups of anomalies in the zone (Fig. 7: groups 4 and 5) pointed to a certain continuity of the burial area from the west. The record of ancient sherds in this zone also supported this. The main anomalies (groups 6 and 7) were 40 meters away from the nearest anomaly (Group 5) and were found at a higher position, reducing the possibility of displacement of the materials from the west side. Minor displacements could have occurred from Group 9, but this was not the case for the concentrations of ash that were attested at this point.

CONCLUSIONS

Current research at HSC highlights the importance of comprehensive data sets to enhance the understanding of historical landscapes and settlement patterns, as well as to protect the area's cultural heritage. Here, riparian space can be considered an attractive factor for the population, providing an advantageous combination of resources and tightly linking the environment to the transformation of human societies. In this respect, the banks of the ancient *lacus Ligustinus* configured a densely occupied historic region where the concept of the 'archaeological continuum' is outstanding. This wetland can be holistically understood only via the *longue durée* perspective, which requires the integration of a large number of scattered pieces of information, both from a vast open space and a long time. Further investigation requires comparative approaches involving definitions of common dynamics for estuarine formations in historical times. Extensive marshlands and remarkable tidal effects should be considered in this respect. The complete examination will consider the ancient perceptions of these wetlands, as attested by literary sources, and the inhabitation solutions and settlement patterns recorded by archaeological research. Investigating HSC provides insight into related trends and elucidates aspects that need thorough consideration. Firstly, and particularly in agricultural lands, in depth transformations of riparian landscapes could have started as early as Neolithic times. Notably, in this respect, there is evidence that marine shellfish gathering coexisted with the Dehesa-type forestry. The related infilling should be understood as gradual processes within the *longue durée*, though the disruptive effects of catastrophic events should not be underestimated. The configuration of waterway networks and terrestrial routes through the marshlands depended on these processes and events. Thus, wetlands can be observed as evolving spaces offering obstacles and possibilities for communication and the appropriation of land. In this sense, we can note the relationship between *Ebora*, Cañada de Burujena, the necropolis in HSC, and the passage through the surrounding marshes. All of these findings relate to our theoretical framework, the study of the *riparia* and a methodological approach to the emptyscape within archaeological fieldwork.

Regarding the strategic fieldwork design, comprehensive data sets and complementary methods confirmed the initial hypothesis of identifying an Iron Age necropolis, as attested by the location of singular materials, radiocarbon dating, and magnetometry. The collection of other samples, such as diagnostic sherds and charcoals for new radiocarbon dating, provides opportunities to further investigate the hypothesis of prolonged use of the necropolis since the 8th century BC.

The assessment of the potential of field archaeology methods considers two aspects: The availability of resources during fieldwork and the generation of enough information for the prosecution of the research. The large quantity of files from the two axial photography sets increases the difficulty of managing these results. This handicap in using drones should be thoroughly considered, for instance, reserving more time and effort to manage the files during fieldwork or restricting the areas to be photographed. The marking of ash concentrations during the field-transect survey resulted in a very functional practice, which enabled us to save time, particularly concerning the later detection of metals. Magnetometry offers possibilities for evaluating risks for surviving structures and planning future excavations, as in the case of the necropolis area. However, from a more urging perspective, negative results from magnetometry should be considered when planning archaeological trenches during fieldwork in zones such as the Neolithic area in HSC, where at the moment, there is no other evidence of surviving underground records.

Concerning the interpretation of the evidence from HSC, several aspects of the environmental context must be highlighted, particularly those related to the watershed as a research unit, as addressed by recent studies within the *riparia* theoretical framework. Human influence on the transformation process of *Ligustinus* can be considered according to the presence of metal pollution from sedimentary infilling. However, additional insight needs to be given regarding the agricultural practices in the surrounding areas. The record from HSC points to an early impact, with a Dehesa-type landscape during the Neolithic and other forestry practices during the Iron Age. To properly assess the effects of related human activities, recognizing species from riparian lowlands in archaeobotanical records can be an exciting aim for future research. Furthermore, communication systems could be investigated using various techniques, such as geological cores and archaeological prospection. One example of this approach considers the Algaida spit and Caño Cardales in the case case of *Ebora*. This type of item can focus a significant part of the research from the emptyscape approach.

Regarding the interpretation of settlement patterns, the HSC study case points to a thorough consideration of the bias of the surface archaeological record. Contamination and hydrotopographical effects have been mentioned, but beyond these factors, difficulties in detecting archaeological sites are demonstrated by negative results in HSC. Identifying surface evidence from the necropolis required several interventions in the zone; moreover, discovering the Neolithic settlement was achieved only after the in-depth plowing. Consequently, HSC was not integrated within the nearby boundaries of the official protection area of Cortijo de Évora, which could have prevented partial destruction of the site. In addition to other modern activities, deep plowing involves gradual and constant damage to archaeological heritage, as has occurred in the nearby necropolis of Mesas de Asta. GIS modeling and predictive analyses are suggested for future research, both for a better understanding of settlement patterns and for the protection of archaeological heritage sites. Observed topographical factors and considerations about visibility and terrestrial communications in HSC can offer insights into some aspects of developing such lines of research. Functional approaches to settlement patterns and spatial analysis can be used to research emptyscape, as in the case of ancient necropolis locations.

Our conclusion of this paper, as gained from the LiguSTAR Project's experience in HSC, concerns the criteria for selecting study zones regarding ancient landscapes, research methods, and relevance of data. Riparian spaces are changing environments, which adds complexity to landscape archaeological research. Nevertheless, intense human-environment interactions and the vulnerability of such spaces offer singular opportunities to investigate historical phenomena and dynamics. The bias of surface records and the limits of remote sensing and field surveys incline us to prioritize intensive research, revisit sites and provide complete terrain coverage. This strategy is particularly encouraging in riparian spaces such as the southern banks of *Ligustinus*, where an archaeological *continuum* is expected due to dense settlement patterns. However, surface records rarely offer paleoenvironmental data, which are fundamental for landscape studies. To increase the possibility of recording these data, future research plans should consider the transformation dynamics of the territory and consequently choose study zones. New agricultural practices and infrastructure can bring this relevant part of the archaeological record to light. As demonstrated in the case of HSC, synergies between rescue interventions and systematic research can offer the relevant data that are required for further development of landscape archaeology projects.

REFERENCES

Arribas, A., and F. Molina. 1979. *El poblado de Los Castillejos en Las Peñas de los Gitanos (Montefrío, Granada). Campaña de excavaciones de 1971. Cuadernos de Prehistoria de la Universidad de granada. Serie Monográfica* 3. Granada: Universidad de Granada.

Barrionuevo Contreras, F. and M. Torres Ortiz. 2021. "La necrópolis tartésica de Mesas de Asta. Avance de estudio." *Revista de Historia de Jerez* 24: 9-69.

Brotóns Yagüe, F. 2008. "La necrópolis tumular ibérica de El Villar de Archivel (Caravaca de la Cruz, Murcia)." In *I^er^ Congreso Internacional de Arqueología Ibérica Bastetana*, edited by A.M. Adroher Auroux and J. Blánquez Pérez, 23-42. Serie Varia 9. Madrid.

Campana, S. 2018. *Mapping the Archaeological Continuum. Filling Empty Mediterranean Landscapes*. Cham: Springer International Publishing AG. DOI: http://doi.org/10.1007/978-3-319-89572-7_5

Cantillo, J. J. 2014. "Parralejos, un asentamiento neolítico en Vejer de la Frontera." *Real Sociedad Económica de Amigos del País de Vejer* 18: 3-7.

Carbonell, E., M. Guilbaud, and R. Mora. 1983. "Utilización de la lógica analítica para el estudio de tecno-complejos a cantos tallados." *Cahier-Noir* 1: 3-64.

Carriazo, J.M. 1970. *El tesoro y las primeras excavaciones de Ebora (Sanlúcar de Barrameda)*. Madrid: Servicio Nacional de Excavaciones Arqueológicas.

Castillo Pascual, P. and P. Iguácel De la Cruz. 2021. "La geografía del *lacus Ligustinus* en Estrabón 3.1.9." *Studia historica. Historia antigua* 39: 107-134. DOI: https://doi.org/10.14201/shha202139107134

Castro García, M.M. 2020. "The LiguSTAR Project: Archaeological Survey Techniques as Applied to the Study of Roman Settlement on the Riverbanks of the Lacus Ligustinus (Southwest Spain)." *Theoretical Roman Archaeology Journal* 3 (1): 1-22. DOI: https://doi.org/10.16995/traj.418

Castro García, M.M., Á.D. Bastos Zarandieta, and J.A. Bocanegra Barba. 2014. "Riparia Environments in Hispania Ulterior Baetica: The Case of the Lagoon of La Janda and the Estuary of the Barbate River." In *Riparia, un patrimoine culturel. La gestión intégrée des bords de l'eua*, edited by E. Hermon and A.Watelet, 67-78. BAR International Series 2587. Oxford: Archaeopress.

Catalán González, F.J., L. Benítez de Lugo Enrich, J.A. Ruiz Gil, and I. Rondán Sevilla. 2022. "The Iron Age Necropolis of El Toro (Alcubillas, Ciudad Real-Spain)—Combination of Archaeological and Geophysical Techniques with Ground Penetrating Radar in the Area around the Jabalón River". *Land* 11(12), 2288. DOI: https://doi.org/10.3390/land11122288

Conolly, J. and M. Lake. 2009. *Sistemas de Información Geográfica aplicados a la arqueología*. Barcelona: Bellaterra.

Córdoba Alonso, I. and D. Ruiz Mata. 2000. "Sobre la construcción de la estructura tumular del Túmulo 1 de Las Cumbres (Castillo de Doña Blanca)." In *Actas del IV Congreso Internacional de Estudios Fenicios y Púnicos: Cádiz, 2 al 6 de octubre de 1995*, edited by M. Barthélemy and M.E. Aubet Semmler, M.E., vol. 2, 759-770.

Díez, C.M., I. Trujillo, N. Martínez-Urdiroz, D. Barranco, L. Rallo, P. Marfil, and B.S. Gaut. 2015. "Olive domestication and diversification in the Mediterranean Basin." *New Phytologist* 206: 436-447. DOI: http://dx.doi.org/10.1111/nph.13181

Domínguez-Bella, S. and M. Pérez. 2008. "La industria lítica pulimentada en la Prehistoria reciente de la Banda Atlántica de Cádiz. Análisis mineralógico y petrológico, materias primas y análisis tecnológico." In *La ocupación prehistórica de la campiña litoral y Banda Atlántica de Cádiz*, edited by J. Ramos, 199-212. Sevilla: Junta de Andalucía.

Domínguez-Bella, S., J. Ramos, J.M. Gutiérrez, and M. Pérez. 2010. *Minerales y rocas en las sociedades de la Prehistoria*. Cádiz: Universidad de Cádiz.

Escacena Carrasco, J.L. 2014. "El desembarco de Noé. Sobre la primera neolitización de la paleoensenada bética." In *Ex illo tempore. Actas de las I Jornadas de Arqueología del Bajo Guadalquivir*, edited by M.J. Parodi Álvarez, 59-129. Sanlúcar de Barrameda.

Ferrer Albelda, E. 2012. "Confusiones contemporáneas sobre geografía antigua. A propósito del *sinus Tartesii* y del *lacus Ligustinus*." *Spal* 21: 57-67. DOI: http://dx.doi.org/10.12795/spal.2012.i21.03

Ferrer Albelda, E. and F.J. García Fernández. 2008. "Cerámica turdetana." In *Cerámicas hispanorromanas. Un estado de la cuestión*, edited by D. Bernal Casasola and A. Ribera i Lacomba, 201-220. Cádiz: Universidad de Cádiz.

García Cardiel, J. 2021. "Domeñando el tiempo y el espacio. La instrumentalización del rito y la memoria en la necrópolis de La Albufereta, Alicante, en el s. III a.C." *Zephyrus* 88, julio-diciembre: 111-134.

García-Viñas, E. and E. Bernáldez Sánchez. 2018. *No hay historia sin basura. Los paleobasureros de la Edad del Hierro en el entorno del* lacus Ligustinus. Sevilla: Universidad de Sevilla.

García-Rivero, D., E. García-Viñas, G. Pérez-Jordà, R. Taylor, E. Bernáldez-Sánchez, and L. Peña-Chocarro. 2022. "Human Ecology and the Southern Iberian Neolithic: An Approach from Archaeobotany and Archaeozoology." *Journal of Field Archaeology* 47(8): 536-555. DOI: https://doi.org/10.1080/00934690.2022.2135248

González-Regalado, M.L., G. Monge, M.I. Carretero, M. Pozo, J. Rodríguez-Vidal, L.M. Cáceres, M. Abad, J.M. Campos, J. Bermejo, J. Tosquella, T. Izquierdo, M.I. Prudêncio, M.I. Dias, R. Marques, P. Gómez, A. Toscano, V. Romero, and F. Ruiz. 2020. "Imprints of historical pollution and the 218-60 BCE tsunamigenic period in southwestern Spain." *Revista Mexicana de Ciencias Geológicas* 37(1): 89-97. DOI: https://doi.org/10.22201/cgeo.20072902e.2020.1.1543

Gómez Peña, Á. 2018. "Nueva propuesta sobre la simbología de la diadema del tesoro de Ébora." *Archivo Español de Arqueología* 91: 67-88. DOI: https://doi.org/10.3989/aespa.091.018.004

Guerra, L.; C. Veiga-Pires, M.L. González-Regalado, M. Abad, A. Toscano, J.M. Muñoz, J. Rodríguez Vidal, L.M. Cáceres, T. Izquierdo, M.I. Carretero, M. Pozo, G. Monge, J. Tosquella, P. Gómez, V. Romero, M. Arroyo, and G. Gómez. 2020. "El contraste micropaleontológico de la Historia: el *Lacus Ligustinus* romano." *Estudios Geológicos* 76(2): e131. DOI: https://doi.org/10.3989/egeol.43851.585

Hermon, E. 2014. "L'Empire Romain: un paradigme du modèle de gestion intégrée de riparia?" *Riparia*, 0: 1–21. DOI: http://doi.org/10.25267/RIPARIA.2014.v0.01

Hermon, E. 2020. *La colonie romaine: espace, territoire, paysage. Les Gromatici entre histoire et droit pour la gestión des ressources naturelles*. Besançon: Presses Universitaires de Franche-Comté.

Hermon, E. 2021. "Aspects de l'histoire environnementale compare: la gestión intégrée de l'eau (GIRE) dans la perspective de bassin versant." *Riparia* 7: 1-22. DOI: http://doi.org/10.25267/Riparia.2021.v7.01

Hermon, E. 2022. “Représentations sociales de l’Antiquité à nos jours: d’une valeur socialisé à une fonction socialisante dans la perspective de la gestion intégrée des milieux des bords de l’eau –Riparia– par bassin versant.” *Riparia* 8: 1-32. DOI: http://doi.org/10.25267/Riparia.2022.v8.01

Lagóstena Barrios, L.G. 2014. “La percepción de la ribera en la costa atlántica de la *provincia Hispania Ulterior Baetica*. El *lacus Ligustinus*.” In *Riparia, un patrimoine culturel*, edited by E. Hermon and A. Watelet, 187-197. Oxford: Archaeopress.

Lagóstena Barrios, L.G. 2015. “*Riparia*: conceptualización histórica, función territorial y aprovechamiento de los humedales en la Bética romana.” In *Aquae Ductus. Actualité de la recherche en France et en Espagne*, edited by L. Borau, L. and A. Borlenghi, 219-232. Bordeaux: Aquitania.

Lagóstena Barrios, L.G. 2016. “El *lacus Ligustinus* como agente de articulación urbana y conectividad territorial: de las riberas de *Hasta Regia* a *Carissa Aurelia* y el acceso a la serranía.” *Studia histórica. Historia antigua* 34: 63-86.

Lagóstena Barrios, L.G. 2021. “Estructura de la ocupación rural romana en las campiñas hastenses: problemática y aportación de la exploración GPR a su conocimiento.” In *Arqueología y sociedad de los espacios agrarios: en busca de la gente invisible a través de la materialidad del paisaje*, edited by V. Mayoral, I. Grau, and I. Bellón, 109-117. Madrid: Consejo Superior de Investigaciones Científicas.

Lagóstena Barrios, L.G. and E. Aragón Núñez. 2023. “The Contribution of GPR to the Historical Research of Urban and Rural Landscapes of Antiquity.” *Land* 12: 1165. DOI: https://doi.org/10.3390/land12061165

Lagóstena Barrios, L.G., M.M. Castro García, and Á.D. Bastos Zarandieta. 2015. “Riparia Concept: Roman Intervention in the Lacustrine Environment of Fuente De Piedra (Málaga, Spain).” In *TRAC 2014: Proceedings of the Twenty-Fourth Annual Theoretical Roman Archaeology Conference, Reading 2014*, edited by T. Brindle, M. Allen, E. Durham, E., and A. Smith, 100-113. Oxbow Books. DOI: http://doi.org/10.16995/TRAC2014_100_113

Lagóstena Barrios, L.G., J.A. Ruiz Gil, D. Martín Mochales, J. Pérez Marrero, I. Rondán Sevilla, P. Trapero Fernández, F.J. Catalán González, and M. Ruiz Barroso. 2021. “El establecimiento rústico alto-imperial de Miramundo (Puerto Real, Cádiz). Un caso de estudio mediante combinación de técnicas de investigación no invasivas.” In *Estudos Arqueológicos de Oeiras* 29, edited by C. Gonçalves, D. García, M.I. Dias, N. Bicho, R. Taylor, M. García-Heras, and J.L. Cardoso, 57-64. Oeiras: Câmara Municipal.

Langgut, D., R. Cheddadi, J.S. Carrión, M. Cavanagh, D. Colombaroli, W.J. Eastwood, R. Greenberg, T. Litt, A.M. Mercuri, A. Miebach, N. Roberts, H. Woldring, and J. Woodbridge. 2019. “The origin and spread of olive cultivation in the Mediterranean Basin: The fossil pollen evidence.” *The Holocene* 29(5): 902-922. DOI: https://doi.org/10.1177/0959683619826654

López Cachero, F.J. 2008. “Necrópolis de incineración y arquitectura funeraria en el noreste de la Península Ibérica durante el Bronce Final y la Primera Edad del Hierro.” *Complutum* 19(1): 139-171.

López Sáez, J.A., P. López García, and M. Martín Sánchez. 2001. “Análisis palinológico del yacimiento arqueológico de Pocito Chico (El Puerto de Santa María): el paisaje prehistórico y protohistórico durante el Holoceno reciente en las marismas de Cádiz.” *Cuaternario y Geomorfología* 15(1-2): 45-59.

López Sáez, J.A. and P. López García (eds.). 2003. “The prehistoric landscape in the Bay of Cádiz: Palynological Análisis at Castillo de Doña Blanca site (El Puerto de Santa María, Spain).” In *Quaternary climatic changes and environmental crises in the Mediterranean Region*, edited by M.B. Ruiz Zapata, M. Dorado Valiño, A. Valdeomillos Rodríguez, M.J. Gil García, T. Bardají Azcárate, I. De Bustamante Gutiérrez, and I. Martínez Mendizábal. Alcalá de Henares: Universidad de Alcalá de Henares.

Martín Ruiz, J.A. 2018-2019. “El tesoro de Ebora ¿Conjunto sacro de un santuario turdetano?” *Takurunna* 8-9: 93-118.

Martín-Arroyo Sánchez, D.J. 2018. *Colonización romana y territorio en Hispania. El caso de Hasta Regia*. Barcelona: Universitat de Barcelona.

Mayoral Herrera, V., C. Pro Muñoz, J. García Sánchez, M.T. De Tena Rey, J.M. Terrón López, E. Quirós Rosado, and A. Gil Llorente. 2023. “Exploración no invasiva de un poblado fortificado de la etapa tardorrepublicana en el valle del Tajo. El Cerro de la Breña (Talaván, Cáceres).” *Spal* 32(2): 180-208. DOI: https://dx.doi.org/10.12795/spal.2023.i32.16

Menanteau, L. and J.-R. Vanney. 2011. “Geohistoria de la desembocadura del Guadalquivir.” In *El río Guadalquivir, del mar a la marisma: Sanlúcar de Barrameda*, edited by J. Rubiales, 17-27. Sevilla: Junta de Andalucía.

Rosen, A.M. 2024. “The Arc of the Anthropocene. Deep-Time Perspectives from Environmental Archaeology.” In *Anthropology and Climate Change: From Transformations to Worldmaking*, edited by S.A. Crate, and M. Nuttall. Routledge. DOI: https://dx.doi.org/10.4324/9781003242499-3

Pachón Romero, J.A. and J. Carrasco Rus. 2005. “Sobre la necrópolis tumular protohistórica de Pinos Puente (Granada). Una revisión.” *Revista del Centro de Estudios Históricos de Granada y su Reino* 17: 15-68.

Parodi, M.J., J. Rodríguez, P. Garrido, and J. Verdugo. 2019. *Carta Patrimonial de Sanlúcar de Barrameda I. Arqueología*. Sanlúcar de Barrameda: Ayuntamiento de Sanlúcar de Barrameda.

Ramos Muñoz, J., M. Valverde Lasanta, J.L. Romero Sánchez, and A. Almagro Blázquez. 1991-1992. "La tecnología lítica de la transición del Neolítico a la Edad del Cobre en la zona centro-occidental de Cádiz." *Zephyrus* 44-45: 207-221.

Rodríguez-Ramírez, A.; E. Flores-Hurtado, C. Contreras, J.J.R. Villarías-Robles, G. Jiménez-Moreno, J.N. Pérez-Asensio, J.A. López-Sáez, S. Celestino-Pérez, E. Cerrillo-Cuenca, and Á. León. 2014. "The role of neo-tectonics in the sedimentary infilling and geomorphological evolution of the Guadalquivir estuary (Gulf of Cadiz, SW Spain) during the Holocene." *Geomorphology* 219: 126-140.

Rodríguez-Ramírez, A., J.J.R. Villarías-Robles, S. Celestino-Pérez, J.A. López-Sáez, J.N. Pérez-Asensio, and Á. León. 2022. "Extreme-Wave Events in the Guadalquivir Estuary in the Late Holocene: Paleogeographical and Cultural Implications." In *Historical Earthquakes, Tsunamis and Archaeology in the Iberian Peninsula*, edited by M. Álvarez-Martí-Aguilar and F. Machuca Prieto. Natural Science in Archaoelogy. Singapore: Springer. DOI: https://doi.org/10.1007/978-981-19-1979-4_6

Rodríguez-Ramírez, A., J.J.R. Villarías-Robles, J.N. Pérez-Asensio, A. Santos, J.A. Morales, S. Celestino-Pérez, J.A. López-Sáez, Á. León, and F.J. Santos-Arévalo. 2016. "Geomorphological record of extreme wave events during Roman times in the Guadalquivir estuary (Gulf of Cadiz, SW Spain): An archaeological and paleogeographical approach." *Geomorphology* 261: 103-118. DOI: https://doi.org/10.1016/j.geomorph.2016.02.030

Ruiz, A., C. Rísquez, and M. Molinos. 2011. "Túmulos, linajes y clientes: la construcción del paisaje funerario aristocrático en el sur de la Península Ibérica." In *Tumuli e sepolture monumentali nella Protohistoria europea. Atti del convegno internazionale. Celano, 21-24 settembre 2000*, edite by A. Naso, 261-275. Band 5. Mainz: RGZM – Tagungen.

Ruiz Gil, J.A., L. Lagóstena Barrios, J. Pérez Marrero, D. Martín Mochales, P. Trapero Fernández, and J. Catalán González. 2019. "*Villae* y *figlinae* a orillas del *lacus Ligustinus*. Análisis GIS y prospección geofísica en el *territorium* ribereño de *Hasta Regia*." In *Paisajes productivos y redes comerciales en el Imperio Romano*, edited by J. Remesal, V. Revilla, D. Martín-Arroyo, and A. Martín, 115-138. Barcelona: Universitat de Barcelona.

Saito, K. 2023. "A long walk in the Italian countryside: Large-scale geophysical survey within the emptyscapes initiative: Examples from the Grosseto-Roselle valley, South Tuscany, Italy." *Archaeological Prospection* 30(3): 301–310. DOI: https://doi.org/10.1002/arp.1892

Schweingruber, F. 1990. *Anatomie europäischer Hölzer. Ein Atlas zur Bestimmung europäischer Baum-, Strauch- und Zwergstrauchhölzer*. Stuttgart: Haupt.

Tol, G., T. de Hass, J. Sevink, M. Schepers, B. Ullrich, and W. de Neef. 2021. "'There's more than meets the eye': Developing an integrated archaeological approach to reconstruct human-environment dynamics in the Pontine marshes (Lazio, Central Italy)." *Geoarchaeology* 36: 109-129. DOI: https://doi.org/10.1002/GEA.21814

Vijande, E., J. Ramos, D. Fernández, J.J. Cantillo, and M. Pérez. 2019. *La Esparragosa (Chiclana de la Frontera, Cádiz). Un campo de silos neolítico del IV milenio a.n.e*. Sevilla: Junta de Andalucía.

Villalpando, A. and M. Montañés. 2009. "Avance de resultados de las excavaciones arqueológicas realizadas en la SET Parralejos." *Revista Atlántica-Mediterránea de Prehistoria y Arqueología Social* 11: 257-264.

Villalpando, A. and M. Montañés. 2016. "El yacimiento de SET Parralejos, Vejer de la Frontera (Cádiz). Un núcleo de población de la prehistoria reciente en las estribaciones del río Salado de Conil de la Frontera." In *Las sociedades prehistóricas y la Arqueología de Conil en el contexto de la Banda Atlántica de Cádiz*, edited by J. Ramos, J.J. Cantillo, and E. Vijande, 115-124. Málaga: Pinsapar.

Voropaeva, I. and H.P. Stika. 2018. "Plant remains from Roman period town of Obulco (today Porcuna) in Andalusia (Spain)-distribution and domestication of olive in the west Mediterranean region." *Archaeological and Anthropological Science* 10: 865-882. DOI: https://doi.org/10.1007/s12520-016-0405-1

FIGURES AND TABLES

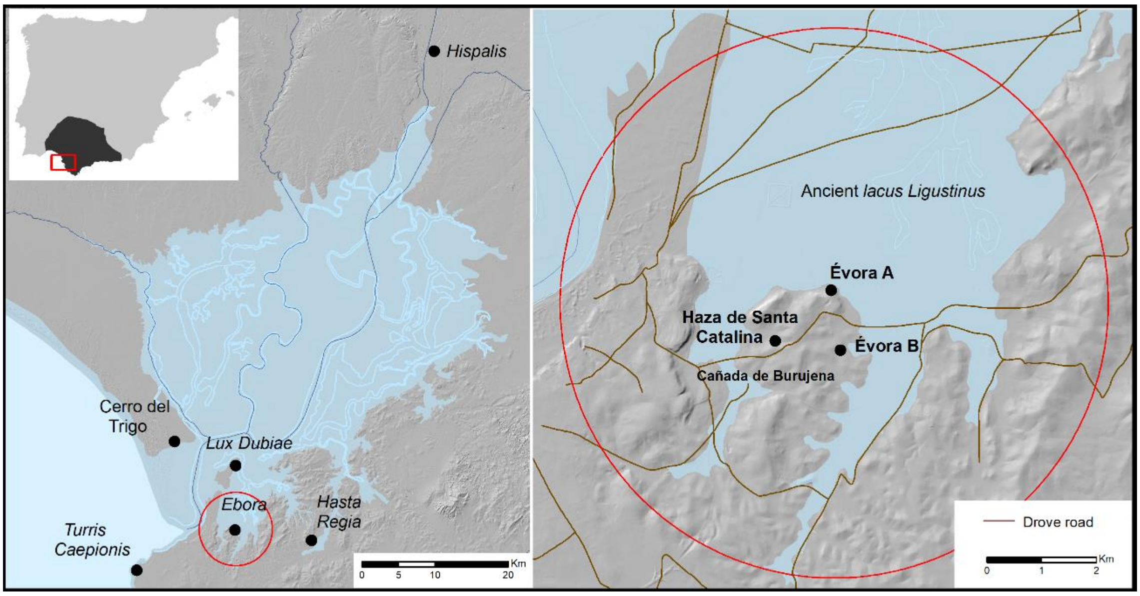

Figure 1. *Ebora and its main surrounding ancient places in the geographical context of lacus Ligustinus (left). Emplacement of Haza de Santa Catalina with respect to Évora A, Évora B, and Cañada de Burujena (right).*

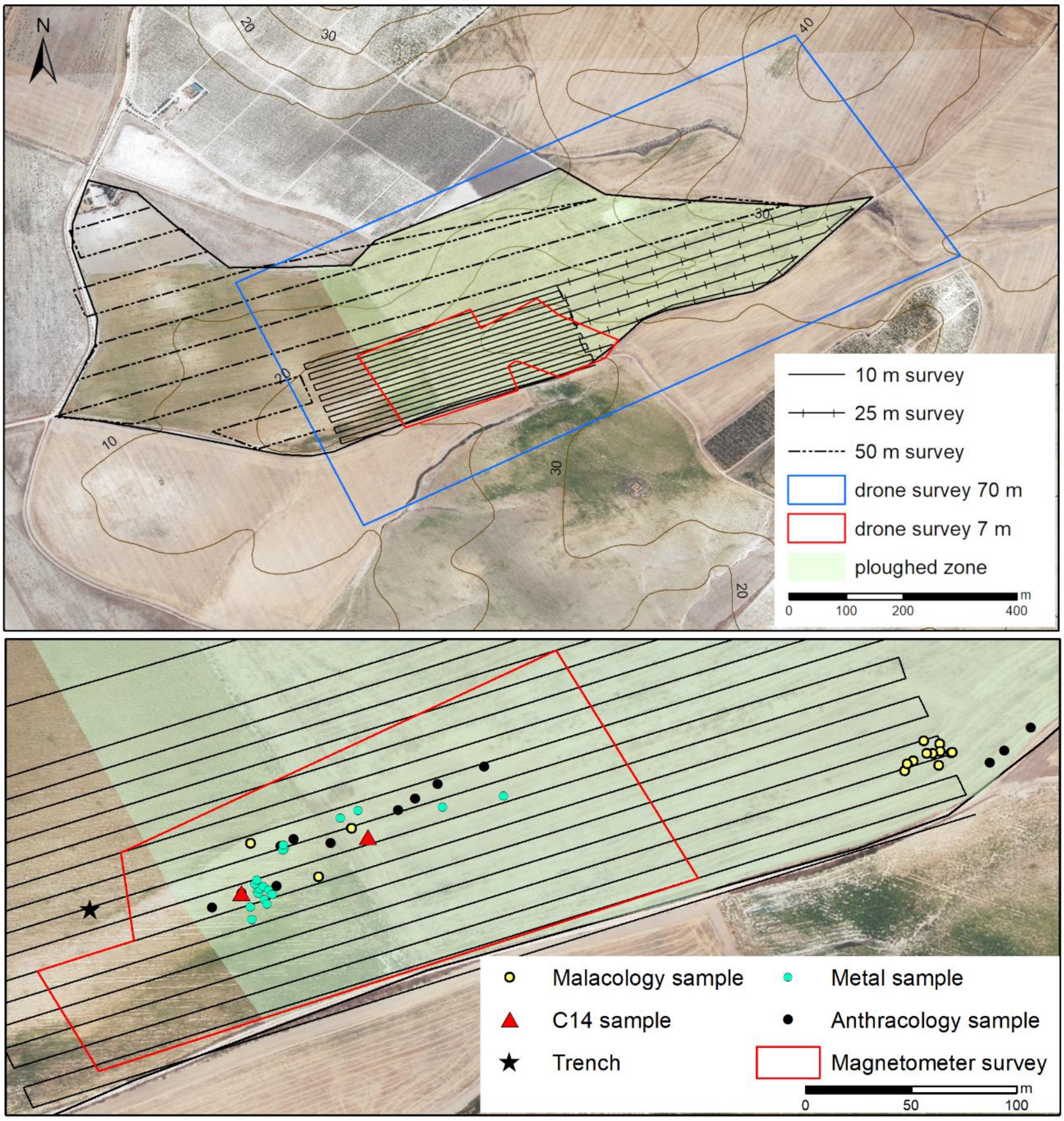

Figure 2. *Field transects and data collection at HSC.*

Figure 3*. State of the plot at HSC after 80 cm-deep plowing (A). Details of a concentration of ash-coal (B) and complete pot (C), both of which are from the necropolis area, and a concentration of vestiges from the Neolithic area (D).*

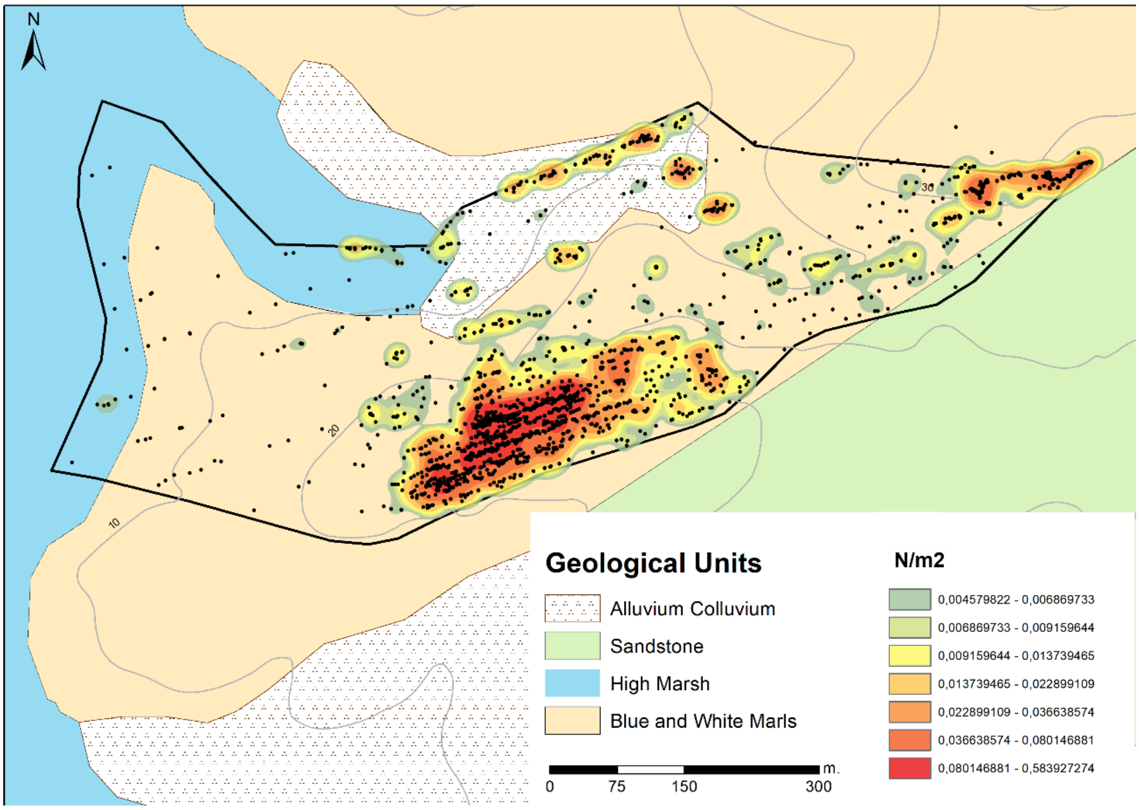

Figure 4. *Kernel density of findings at HSC with respect to the land plot, as well as to the topography and geology of the zone.*

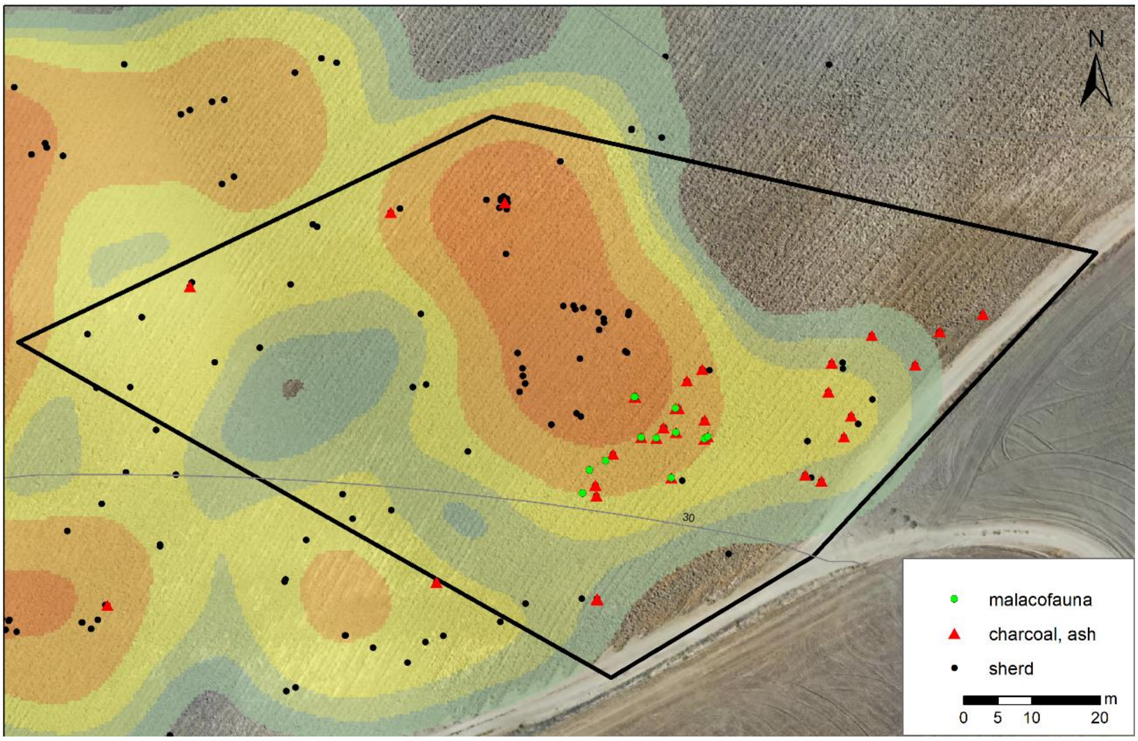

Figure 5. *Neolithic area at HSC. Distribution of findings and samples within Polygon of Protection A-2.*

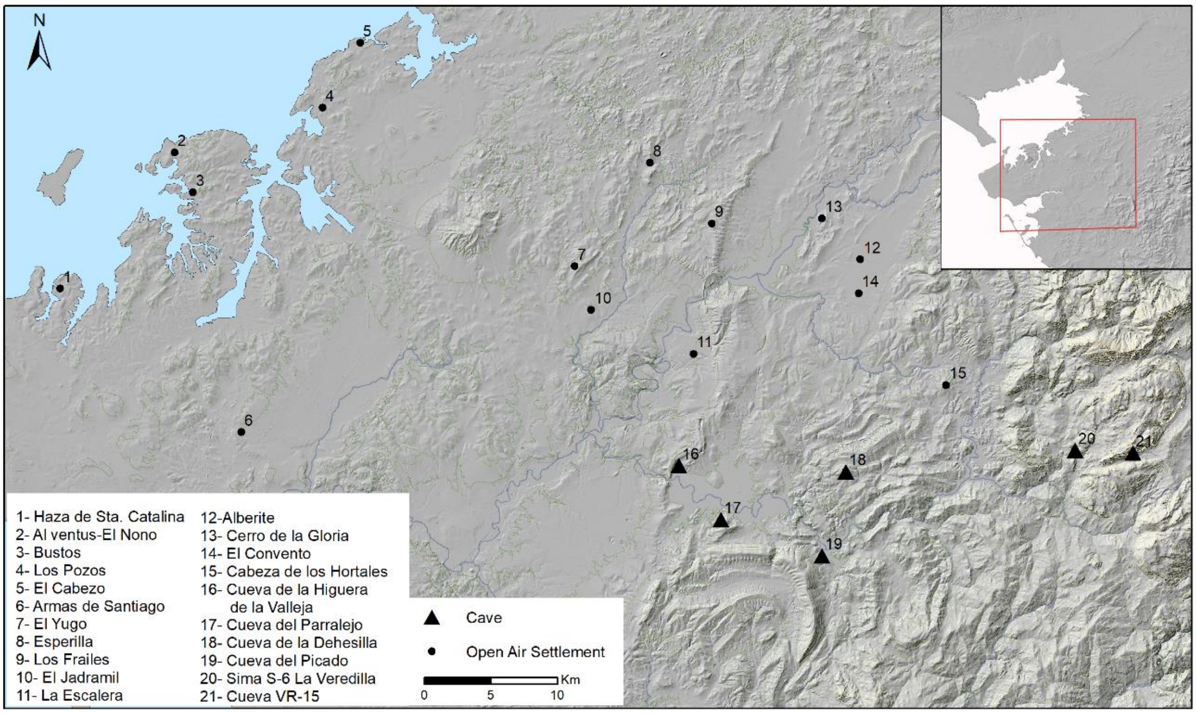

Figure 6. *Locations of HSC and other nearby Neolithic sites.*

Figure 7. *Magnetograms and division by sets of magnetic anomalies in the pre/early Roman area of HSC.*

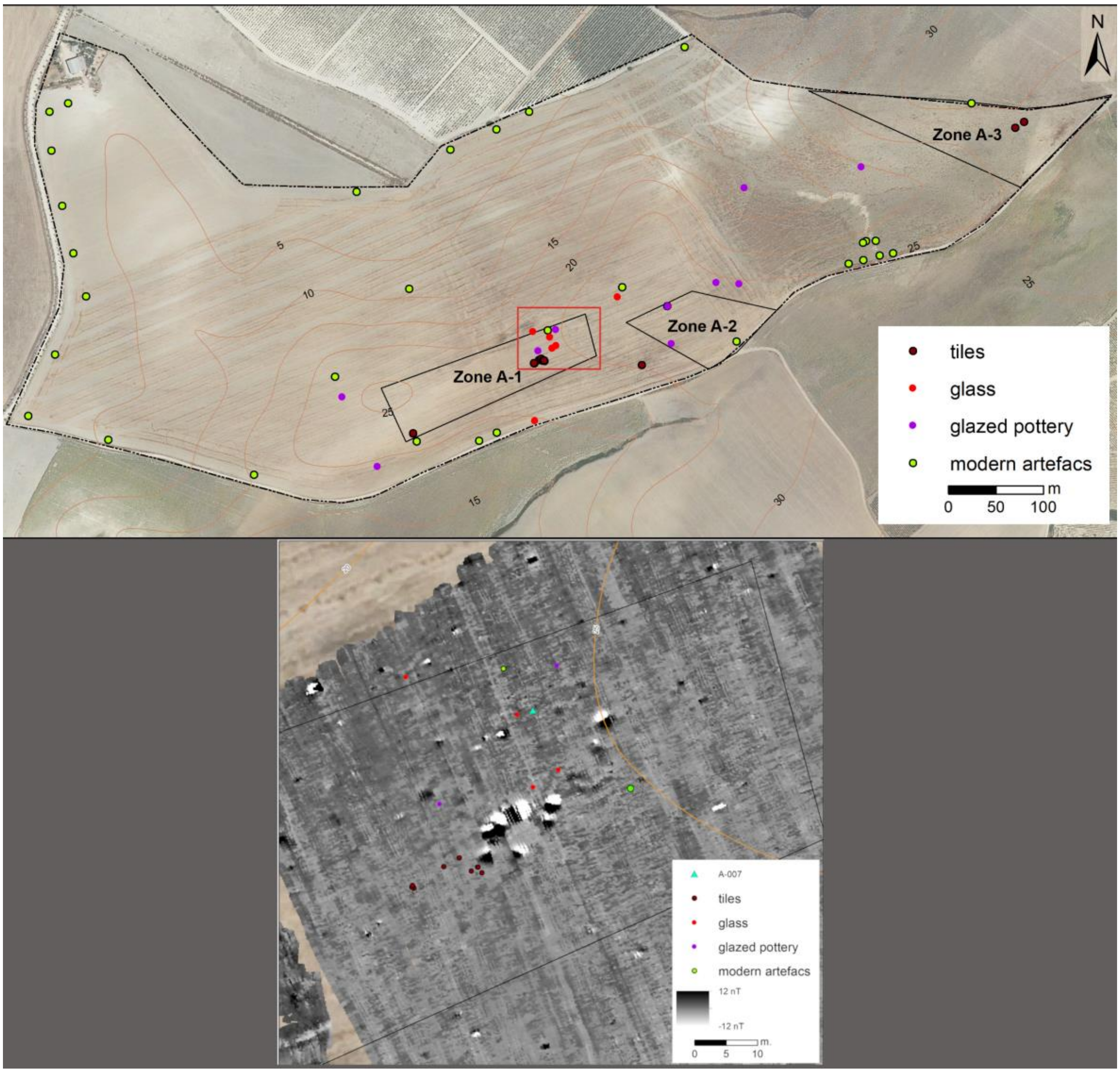

Figure 8. *Evidence of recent contamination and postancient settlement in the HSC land plot. Polygons of protection A 1-3.*

	Grams	Litres
[E179]	1440	1,0
[E176]	7750	4,0
[940]	5145	3,0
[A-001]	1885	1,5
[A-009]	8820	7,0
[D-477]	5860	5,0
[D-497]	7835	6,0
[D-598]	2425	2,0
[E-140]	3270	2,5
[E-154]	1785	1,5
[E-218]	2380	2,0
[E-249]	3535	3,0
[E-255]	6900	5,0
[A-007]	7440	5,0
Total	**66470**	**48,5**

Table 1. *The weight and volume of each paleobotanical sample were measured before flotation.*

	Arbutus unedo/cf. Arbutus unedo	*Ericaceae*	*Olea europea/cf. Olea*	*Oleaceae*	*Pinus pinea/pinaster*	*Pinus sp.*	*Quercus (evergreen)*	*Quercus (deciduous)*	*Quercus sp.*	Indeterminate angiosperms	Indeterminate	Total
[E179]			1						1		1	3
[E176]			1							1	2	4
[940]			10									10
[A-001]	1		6	1	2	3				7		20
[A-009]			2		7	10				1		20
[D-477]			7							12	1	20
[D-497]			17							3		20
[D-598]			12	1	2	4				1		20
[E-140]	1	1	4							11	9	26
[E-154]	2		14							11	1	28
[E-218]			7	1	6	3				3		20
[E-249]		4	13		2	1						20
[E-255]			6		5	7				2	1	21
[A-007]			8				6	2	4			20
Total	4	5	108	3	24	28	6	2	5	52	15	252

Table 2. *Taxonomic identification of charcoals.*