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ABSTRACT
This paper interprets the first archaeobotanical data to emerge from the island of Ustica (northwestern Sicily, Italy). The excavation of the Neolithic site of Piano dei Cardoni (4600-4200 cal BC) and the Middle Bronze Age site of Faraglioni Village (1500-1250 cal BC), has made it possible to analyse plant macro-remains and compare them with data on local vegetation obtained from both historical literary sources and recent field surveys. The onset of agro-pastoral practices in the mid-5th millennium BC brought about significant changes to the local pristine plant communities. Indeed, the presence of holm oaks and pine trees in that period was recently detected for the first time. The evolution of the local vegetation following the first human settlement in the Neolithic has some crucial parallels with what happened following the recolonisation of the mid-eighteenth century. The massive presence of olive trees during the Middle Bronze Age suggests the deliberate introduction of this crop species on the island and attests to olives' paramount importance for the local economy at that time. The disappearance of some woody species shows that human occupation has had a powerful impact on the island's forest resources, which partially recovered during the repeated long phases of land abandonment.

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Neolithic; Middle Bronze Age; vegetation history; historical maps; Mediterranean island; human impact; forest disruption

Introduction and Aims

Small islands have long represented a perfect target for archaeologists and landscape ecologists interested in how local landscapes have changed following the arrival of the first humans, seeking to determine which phenomena – whether climate or human activities – are responsible for these changes and how humans adapted socially, economically, and technologically (Braje et al. 2017; Burjachs, Pérez-Obiol, and Picornell-Gelabert 2017; Connor et al. 2012; Dotte-Sarout and Kahn 2017; Isendahl and Stump 2019; Kirch 2007; Leppard 2017; Picornell-Gelabert and Servera-Vives 2017). The literature is full of remarkable examples of such studies: for example, the Pacific Islands and Caribbean were found to have experienced dramatic impacts on their natural biota, partly as a consequence of animal and plant introductions since the arrival of Europeans. Nevertheless, pre-industrial people also often triggered significant ecological changes (Carroll et al. 2012; de Nascimento et al. 2016; Fitzpatrick and Keegan 2007; Kirch 2004; Kirch and Hunt 1997; Morales et al. 2009; Pagán-Jiménez 2013). Gradually, so-called semi-natural plant communities developed within the newly occupied territories, their existence depending on specific anthropo-zoogenic factors that archaeobotanical remains can help to interpret (Behre and Jacomet 1991). Human impact can devastate small-island vegetation (Dotte-Sarout and Kahn 2017), although after the initial shock and the increase of fire events (like in the Canary Islands, de Nascimento et al. 2016), forest management and agro-forestry can lead to a new ecological balance (e.g. in New Caledonia, Dotte-Sarout et al. 2013), provided that islands are high and big enough to host a large number of habitats. Human disturbance can also lead to the establishment of an open environment, due to pastoral grazing, as in the islet of Cavallo (Poher et al. 2017) or in the Maltese islands (Carroll et al. 2012; Djamali et al. 2013). In most cases, it is responsible for the extinction of species and disappearance of forest cover, as in Mauritius (Cheke and Hume 2008), Rapa Nui (Flenley et al. 1991; Hunt 2007; Wood et al. 2017) or certain areas of Sardinia and Corsica (Médail 2017). The colonisation, overexploitation and subsequent abandonment of small Mediterranean islands are phenomena that

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have been occurring continuously since the Mesolithic (Dawson 2014) and may have triggered sudden, rapid and irreversible changes in local environmental patterns, as attested for more recent times (e.g. Pasta and La Mantia 2003).

With no doubt the natural landscape of Ustica has been altered during almost 7000 years of human occupation, the small island having been repeatedly colonised since prehistoric times. The present-day landscape is mostly the result of the last colonisation, dated to the mid-eighteenth century AD, when a group of 86 families landed from the nearby Aeolian Islands, bringing with them animals, food, and all their belongings (Ailara 2005). According to contemporary authors, holm oaks and manna ash trees, as well as other fruit trees and vegetables, were imported after the occupation (Calcara 1842). Literary sources and historical maps allow us to go nearly 250 years back, returning a picture of the island that is nevertheless the result of millennia of discontinuous human impact and land use that only detailed paleoenvironmental analyses can help disentangling (see e.g. Rackham and Moddy 1996 for Cretan landscape). We gain the result of a palimpsest of human intervention and of biodiversification as historical processes (Cevasco, Moreno, and Hearn 2015), but without a rich dataset of palynological, pedological and archaeobotanical data for all the phases of human occupation, we lose the diachronicity and the depth of these processes. Reconstructing the island's landscape at the moment of prehistoric occupation is therefore an arduous task.

Large mammals were absent from the native fauna of Ustica, hence the introduction of domestic herbivores strongly affected local vegetation (e.g. Centore, Ugarković, and Scaravelli 2018; Hess et al. 2020; Vitousek 1988), as happens even on larger islands (Cañellas-Boltà et al. 2018; Sarà 1998). Climatic conditions have also changed periodically: for instance, during their war against Syracuse (beginning of 5th century BC), the Carthaginians are said to have abandoned 6000 slaves to die on the islet, which had no water (Oldfather 1970), while in the 12th century AD Idrisi reported that Ustica had abundant fresh water (Amari and Schiaparelli 1883). Although the literary sources are not always entirely reliable, it is not unlikely that climate shifts and oscillations in rainfall regime have occurred over the millennia.

Unfortunately, no paleoenvironmental datasets are available for the island. In fact, as many other Mediterranean islands, Ustica is lacking of rivers and permanent water bodies; hence, archaeobotanical data actually represent the best– if not the only – tool to trace past vegetation patterns and to assess with the impact of human activities through time (Asouti and Austin 2005). Furthermore, crossing present environmental data with historical land use maps to evaluate landscape evolution is an increasingly common practice in recent decades (Mazier et al. 2015; Moreno 1995).

The aim of this paper is to interpret the first archaeobotanical data to emerge from excavations in two archaeological sites (the Neolithic site of Piano dei Cardoni, 4600–4200 cal BC and the Middle Bronze Age site of Faraglioni Village, 1500–1250 cal BC). These results, despite their paucity into an archaeobotanical framework that still needs to be implemented, are compared with the data on the island's vegetation arising from recent field investigations and the ones obtained from historical literary sources, seeking to trace and describe the evolution of local plant communities and to evaluate human impact over the millennia. Understanding how the first settled human communities interacted with the island's vegetation represents a key goal for studies of the relationship between humans and the environment on small Mediterranean islands.

The Context

Geographical and Ecological Context

The island of Ustica is an extinct volcano located 60 km North of the Sicily coast, west of the Aeolian islands. The emerged part of Ustica covers an area of less than 9 km^2 and reaches a maximum elevation of 248 m a.s.l., corresponding to the peak of Mt. Guardia dei Turchi in the central part of the island (Figure 1).

Ustica is mainly made of volcanic rock, and to a lesser degree of marine and continental sedimentary deposits. Volcanic rock was produced by both submarine and subaerial effusive and explosive eruptions (De Vita and Foresta Martin 2017). Local volcanic rocky outcrops show high sodium content and alkalinity and are predominantly composed of poorly differentiated hawaiitic to mugearitic products. Trachytic products, deriving from more differentiated magmas, are present to a lesser extent; in the subaerial

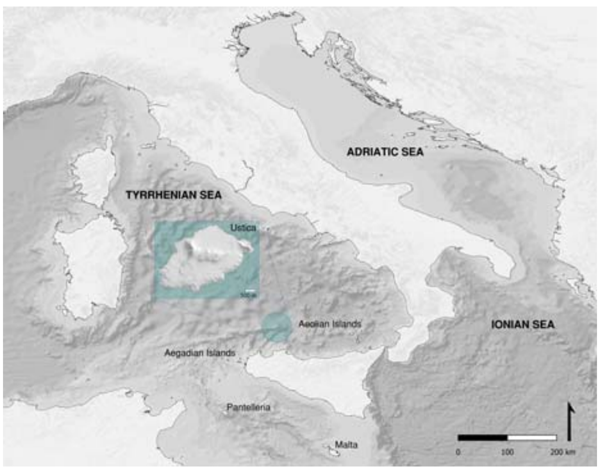

Figure 1. Position of Ustica island in the Tyrrhenian Sea.

part, they consist exclusively of pyroclastic materials. As the volcano ceased to be active after 130 ka BP, it is reasonable to assume that humans experienced only exogenous morphodynamic processes, active on the island in more recent times (Speciale et al. 2020).

The current morpho-structural features of the island are the result of the interaction between volcanism and tectonic phases, dating back to the early Quaternary. In addition, sea level high-stands arising from glacio-eustatic movements during the Middle-Upper Pleistocene caused at least five marine transgressive-regressive cycles, generating five orders of marine terraces (de Vita 1993; De Vita and Foresta Martin 2017; de Vita and Orsi 1994). On the one hand, effusive and low-energy explosive volcanic eruptions involved the rise of a volcanic edifice, with widespread lava flows and the deposition of abundant pyroclastic material, whilst on the other hand marine erosion has partially destroyed the previous reliefs, carving cliffs and creating extensive marine abrasion platforms currently found at a range of heights above sea level (de Vita 1993; De Vita and Foresta Martin 2017; de Vita, Guzzetta, and Orsi 1995; 1998; Furlani et al. 2017) (Figure 2).

Surface erosional features (watersheds, streambeds) are poorly developed and rare, probably due to scarce rainfall and the modest size of the island, which has not allowed the development of a permanent and well-defined hydrographic network. Moreover, the existence of small reliefs surrounded by lowlands has facilitated the formation of thick and widespread surface detrital layers, often deeply humified. There are some temporary ponds, called 'gorghi', often enlarged and deepened by humans across the centuries (Di Stefano and Mannino 1983; Valenza 2019) (Figure 3). Between late spring and summer, these depressions are totally dry, whilst during the rainy season (usually between September and April-May), they collect and retain a certain amount of rainwater (Figure 4a-b).

Based on a thirty-year reference period (1971-2000), the thermo-pluviometric data from the Ustica meteorological station, located at 251 m a.s.l., show

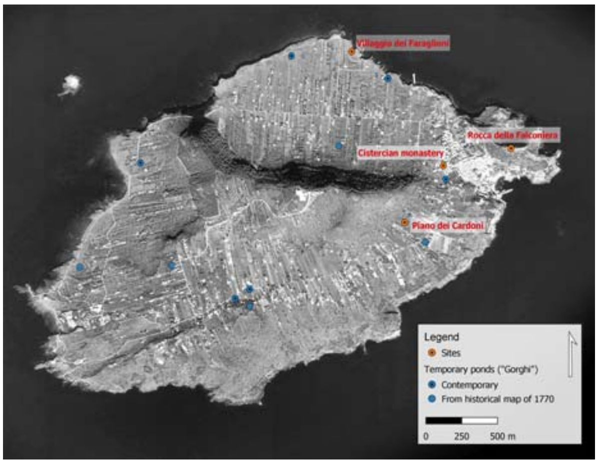

Figure 3. Distribution of the semi-natural temporary ponds called 'gorghi'; the dot identifies the ones today present on the island, while the ones without the dot, only feature in the historical maps; in orange, distribution of the sites cited in the text (map credit: N. Larosa).

that the average temperature of the coldest months, January and February, is around 11 °C, and that of the warmest month, August, is about 25 °C. Average annual rainfall is around 450 mm, with a marked and long-lasting dry season of 4–5 months and a moderate peak in autumn. According to Rivas-Martínez classification, the island's bioclimate is lower thermo-Mediterranean (Bazan et al. 2015).

The few remnant patches of woody vegetation currently occurring on the island are represented by high maquis dominated by olive trees (*Olea europaea* L.). The most common woody species of the undergrowth are the mastic tree (*Pistacia lentiscus* L.) and *Phillyrea latifolia* L., with *Rhamnus alaternus* L., the tree spurge *Euphorbia dendroidres* L. and the perennial grass *Ampelodesmos mauritanicus* (Poir.) T. Durand & Schinz occurring only on the steepest and sunniest slopes. The surfaces of the dry-stone terraces once devoted to the cultivation of cereal crops, vineyards and legume orchards, currently represent a complex patchwork including all the dynamically interconnected steps of local vegetation, i.e. annual swords,

Figure 2. View of Piano dei Cardoni, (southern side of the island) (photo credit: C. Speciale).

Figure 4. a - Gorgo Salato, a pond on the northern side of the island, after seasonal rains (December 2020) (photo credit: C. Speciale); Figure 4b: Gorgo San Bartolicchio, coated with concrete during the 80s, as many others on the island (May 2021) (photo credit: A. Patania).

perennial grasslands, broomfields, and maquis with *Pistacia lentiscus*. More information about the current patterns of local natural and semi-natural vegetation is provided in Supplementary Table 3.

Archaeological Context

The low altitude (and hence low visibility), the almost total lack of freshwater springs, the absence of valuable geological resources like obsidian and the remarkable distance (ab. 60 km) from the north-western coast of Sicily meant that Ustica remained relatively marginal in the trade dynamics of the southern Tyrrhenian Sea during prehistory. Nevertheless, human occupation started at the end of the Middle Neolithic period (around 4600 cal BC), as attested by the recent excavation of Piano dei Cardoni (Speciale et al. 2020, 2021) (Figure 5), which confirmed the spread of Neolithic communities in some areas of the island (Mannino 1998), probably used as a stepping stone in the obsidian trade route and exchanges between the Aeolian islands and western Sicily.

Based on the distribution of pottery and obsidian, the settlement of Piano dei Cardoni occupied an area of about 2 ha; the so far unpublished AMS dates, performed on the animal bones from the stratigraphic units of the latest phase of occupation, confirm the material cultural chronology (4600-4200 cal BC).

The island was occupied throughout the Copper Age (4th millennium BC), with a possible hiatus from the end of the Copper Age to the Early Bronze Age (end of the 4th millennium, beginning of 3rd millennium BC), when a massive new occupation is attested by the village of Faraglioni. By the end of the Middle Bronze Age (from now on MBA), human occupation had spread all over the island, as shown by several surface finds (Procelli 2006) and the presence of the extensive village on the Tramontana plain on the northern side of the island. This village, with a surface of around 7000 m^2, was protected by a high cliff and the sea on the north-eastern side, while on the other sides it was protected by a semicircular fortification wall approximately 6 m thick at the base, with a series of semicircular towers or buttresses (Spatafora 2012) (Figure 6). The huts, built next to each other probably on a stone plinth with walls composed of clay mixed with straw, were mostly ovoid or rectangular with rounded corners, with open spaces nearby. We do not know how the roofs were built, partly due to the absence of post-holes (Spatafora 2016).

Figure 5. Excavation site (photo credit: C. La Bruna, modified by N. Larosa).

At the end of the MBA, the island was abandoned, with only scattered data for the centuries before its reoccupation in Roman times (Vassallo 2020). Around the 3rd century BC, a large settlement was founded on the Rocca della Falconiera (Spatafora 2009) along with some minor settlements, mainly farms, in the flatter areas. The occupation of the island in the late Roman and Byzantine periods lasted until the 6th

Figure 6. View of Faraglioni Village, northern side of the island (photo credit: Regional cluster of Palermo for Archaeological Parks and Museums).

century AD and is documented not only by a series of villages, but also by a large and dense necropolis located on the south-western foothills of Falconiera (Di Stefano and Mannino 1983). After a new phase of abandonment, Ustica became the seat of a Cistercian Monastery in the mid-13th century (Barraco Picone 2010; Maurici 1999) and the island hosted a village of monks and farmers probably up to the 16th century, when it became the strategic target of pirates raiding the trade route between Trapani and Naples. It then lay abandoned until the last colonisation of the eighteenth century.

Recent Evolution of Local Vascular Flora and Vegetation Inferred from Literature

No palaeobotanical data are available on the vegetation cover before the arrival of humans on the island, with the exception of some fossilised imprints of the leaves of the dwarf palm (*Chamaerops humilis* L., currently absent in the island) found in the volcanic ashes of the island, dated to approximately 130.000 years ago (De Vita and Foresta Martin 2017; Romano and Sturiale 1971; Stella Starrabba 1925). Nevertheless, scattered data on the vascular flora of Ustica were reported by several voyagers and scholars who visited the island just before and just after its recolonisation (Ucria (da) 1789; Smyth 1824; Gussone 1832-1834; 1842-1845; Calcara 1842). Specifically, the first and only author providing reliable information on the 'natural' landscape and on the occurrence of olive forest nuclei on Ustica before the re-establishment of a human settlement on the island was Pigonati (1762), as further explained in the results section. Ucria (da) (1789) mentioned the local occurrence of two coastal plants, *Limonium sinuatum* L. and *Limoniastrum monopetalum* (L.) Boiss., both now absent from the island. Subsequently, Gussone explored the island during spring 1828 and provided an initial checklist of local vascular flora, partially enriched by Calcara's findings. From the 1840s to the 1870s, two plant gatherers, V. Messina and D. Reina, were sent to Ustica on behalf of the Botanical Garden of Palermo, and some of their original findings and samples were mentioned by Lojacono-Pojero (1888-1909). In the same years Habsburg Lothringen (1898) provided some additional details on local flora and agricultural practices.

More than a century after Gussone and Calcara, a second checklist of local vascular flora was published by Ronsisvalle (1973). During the following decades, many studies of Ustica's landscape and biogeographical patterns were published (Pasta and La Mantia 2013 and references therein). In addition, the inventory of local cultivated landraces (Hammer, Laghetti, and Perrino 1999; Laghetti et al. 1998), the ethnobotanical paper by Lentini, Di Martino, and Amenta (1996) and numerous agronomic studies (e.g. Barbera, Di Lorenzo, and Barone 1991; Gristina et al. 2017;

Piergiovanni 2000) all highlighted the importance of Ustica's agricultural heritage, emphasizing the strongly rural character of the island's landscape, shaped by local inhabitants. Botanical research was given a new impetus by Carratello, Gambino, and Raimondo (1991), Schicchi (1999) and Argentieri (2001), who discovered some 20 species new to the local flora. Subsequently, Giardina, Raimondo, and Spadaro (2007) described *Limonium usticanum*, a sea-lavender considered endemic to the island and very close to *L. bocconei*, growing along the rocky coasts of NW Sicily and Egadi islands. More recently, Pasta et al. (2007) provided a synthesis of literature data and an updated checklist of local vascular flora based on the field investigations carried out from September 2006 to May 2007. This census, together with an outline of local vegetation, was included in the Management Plan of local Natura 2000 Site (AA. VV. 2009). According to this source, the island still hosts approximately 400 vascular plant taxa, whilst more than 50 taxa, mostly linked to anthropogenic habitats such as extensive crop fields, have probably become extinct during the last half century as a consequence of the abandonment of traditional agricultural lands and practices.

Materials and Methods

During the excavation of Area 2 (year 2019) of the site of Piano dei Cardoni, soils were systematically collected in accordance with standard procedure (Pearsall 2015) for around 20 liters per layer. All the samples contaminated by modern seeds or charcoals were not considered in this paper. The layers 2, 7, 9, 10, 12, 13, 18, 21, 24, 25 (phases of use and abandonment of the last occupation of the settlement) (Figure 7) were then subsampled (around 2 liters per sample) and water-sieved on site using a 0.5 mm mesh. Unfortunately, most of the plant material proved to be badly preserved. The wood charcoal specimens mostly range from 0.5–2.0 mm in width and they are not always recognisable in three dimensions. Remains were selected by hand with a magnifying lens (×4) and then examined with a metallographic trinocular microscope Optika B-383MET (up to 50×). As for the most superficial layers, when the record was not considered reliable due to the presence of modern contamination, data were excluded from the analyses. Due to the reduced number of specimens, we mostly analysed the data with an absence/presence standard.

The samples from the Faraglioni Village were only collected in two small quadrangular rooms, XXV and XXVI, on the west side of a large open area located in a fairly central part of the village. The typological features of the archaeological finds and the mode of deposition suggested that this space was intended for cult activities. On the floor of the open space were burnt bones of sheep, goats and cattle, associated with pottery (often intentionally shattered) and some miniature ceramic forms. Inside the rooms, a

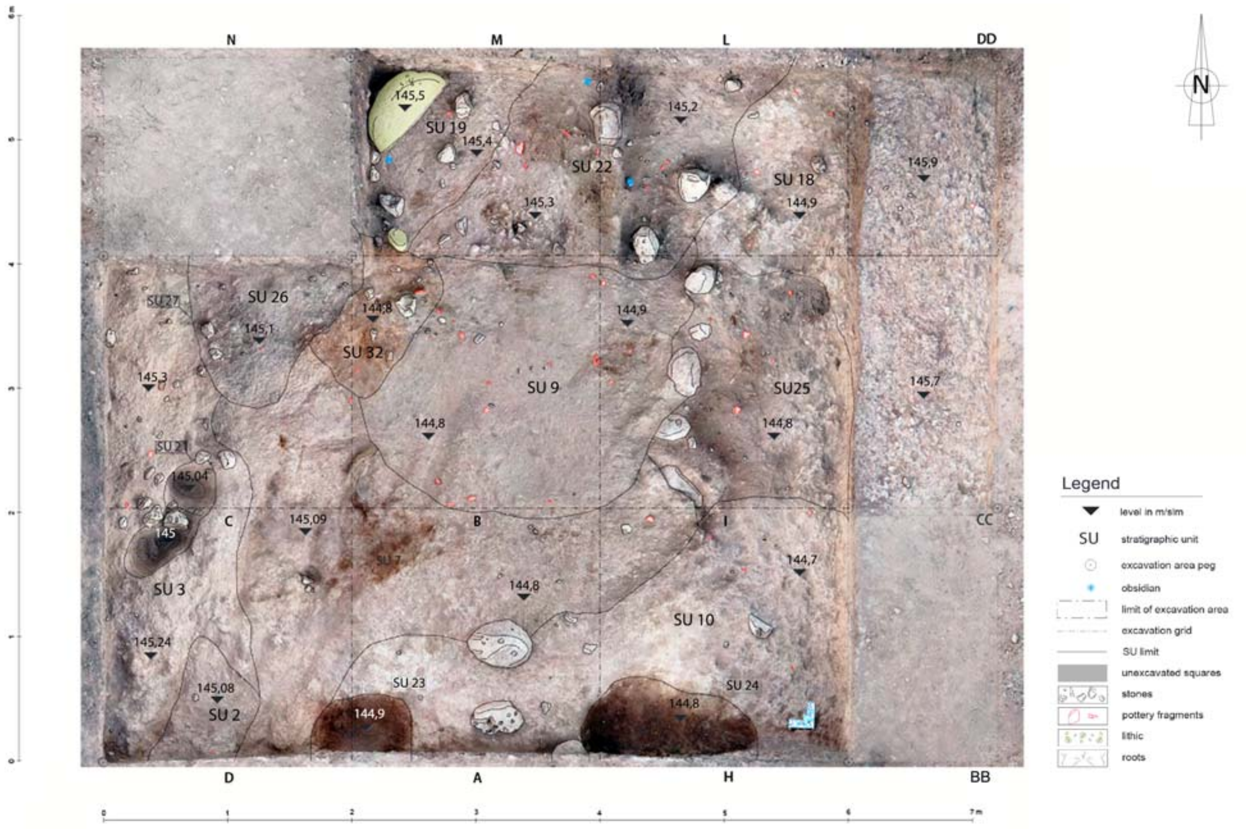

Figure 7. Archaeological phase map, 2019 (photo credit and editing Nunzia Larosa).

millstone platform and a series of jars linked to the activities that took place there were also found.

The samples examined were retrieved from the infill of jars - RA 175 from hut XXV and RA 165, RA 166, RA 148, RA 157 from hut XXVI - and some small holes dug in the floor of hut XXVI (Stratigraphic Units 569a, 569b, 574) (Figure 8a-b). The infills belong to the phases of use of the area.

Given the characteristics of the context and the low-clay matrix, the samples were analysed without flotation, to avoid dispersal or crushing of the remains. No samples exceeded 2 liters and the remains were screened by hand with a magnifying (×4) lens. The samples were subsequently analysed under the 20× Wild Heerbrugg binocular microscope at the Di.S.-Te.B.A. (Department of Biological and Environmental Sciences and Techniques) of the University of Salento. Photographs of the seeds were taken by means of a stereomicroscope and a part of the wood charcoal was selected for SEM analysis. All samples were mounted on aluminium stubs and coated with three layers of gold before observation at SEM ZEISS EVO HD 15.

For identification of the woody species, reference atlases (Cambini 1967a, 1967b; Nardi-Berti 2006; Schweingruber 1990), scientific literature (i.e. Asouti et al. 2015), and online tools – InsideWood, https://insidewood.lib.ncsu.edu and Microscopic Wood Anatomy, http://www.woodanatomy.ch/ - were used. In addition, identification was supported by direct comparison with wood samples of the putatively identified species present in the 'A. Fiori Xylotomotheca Italica' collection available in the Laboratory of General Botany (University of Salento). Due to their very low density in the soils, all the wood charcoals and seeds were observed.

The nomenclature of all the plant species quoted in the text follows Pignatti et al. (2017-2019).

Results

Piano dei Cardoni - Middle/Late Neolithic (4600-4200 cal BC) (Table 1)

Despite the very poor state of conservation of the remains, an initial attempt to identify the specimens was performed. Rather surprisingly, our preliminary results not only highlighted the occurrence of woody species which are still present on the island, such as *Rhamnus/Phillyrea*, *Euphorbia dendroides*, *Pistacia lentiscus*, cf. *Smilax aspera* L., cf. *Lonicera implexa* Aiton, *Erica* sp., Rosaceae cf. *Pyrus* sp., but also tree species such as *Quercus* cf. *ilex* and *Pinus* cf. *pinea/halepensis*. A record of a woody monocot suggests the presence of *Chamaerops humilis* L. until the 5th millennium BC, although this finding warrant confirmation.

A small quantity of chaff remains (one rachis and one fork) of *Triticum* cfr. *dicoccum* was found, but this preliminary classification is not supported by the identification of kernels. *Hordeum vulgare* (hulled barley) was found in very small amounts (Figure 9).

Faraglioni - Middle Bronze Age (1400-1200 cal BC) (Table 2)

Analysis of the soils showed a very low presence of macro-remains, although both wood charcoal and

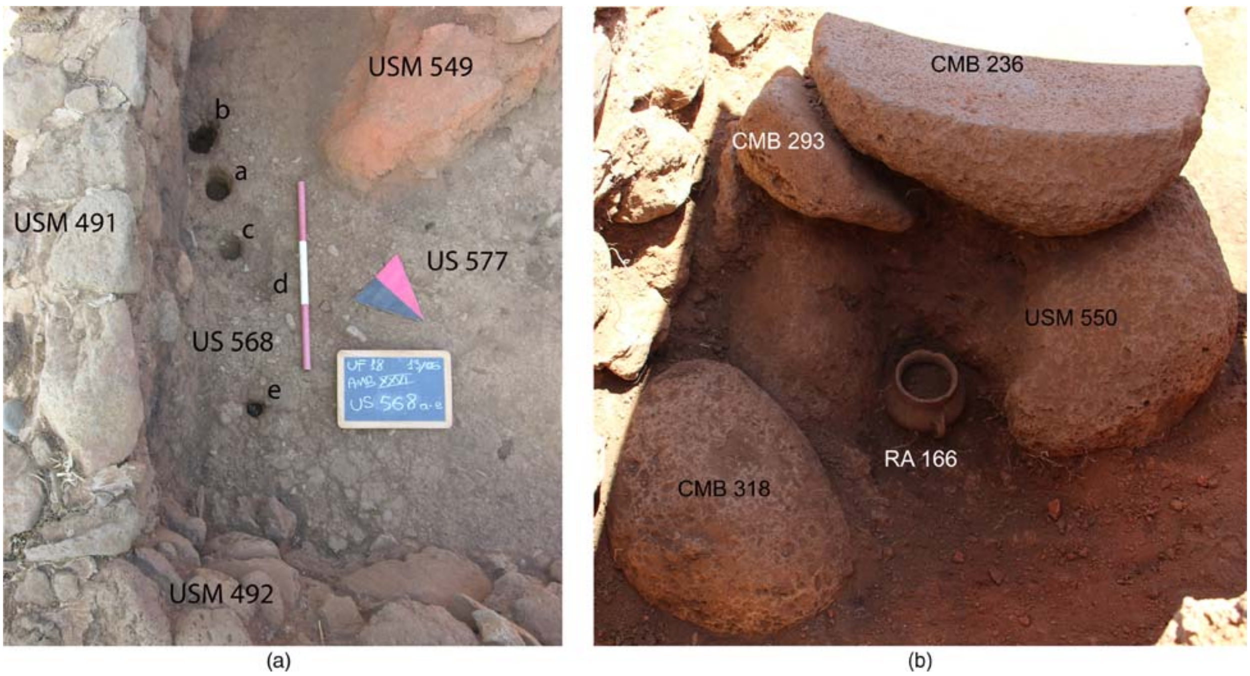

Figure 8. a: Vessel RA166, one of the sampled contexts; Figure 8b: Layers 569 inside layers 568, some of the sampled pits (photo credit: Regional cluster of Palermo for Archaeological Parks and Museums).

Table 1. Piano dei Cardoni – year 2019.

Wood charcoals	No.
Quercus cf. *ilex*	12
Pinus pinea/halepensis	5
cf. *Pyrus* sp.	4
Rhamnus/Phillyrea	13
cf. *Lonicera implexa*	2
Pistacia lentiscus	7
Euphorbia dendroides	8
cf. *Olea* sp.	2
cf. *Erica* sp.	3
cf. *Smilax aspera*	3
Chamaerops humilis	8
Monocot	3
Unidentified	26
Total	96
Seeds	No.
Triticum sp. (rachis)	1
Triticum cfr. *monococcum* (fork)	1
Triticum cfr. *dicoccum* (kernel)	1
Hordeum vulgare (kernel)	1
Rumex acetosa	1
Lamiaceae	1
Rubiaceae	1
Unidentified	6
Total	13

seeds were found in layers 569a, 569b and 574. Most of the wood fragments found in layer 574 and vessels RA 148, RA 166 and RA 175 were identified as belonging to *Olea europaea* (Figure 10a-b) – in some cases small branches (Théry-Parisot, Chabal, and Chrzavzez 2010) and one of them possibly to *Phillyrea*/*Rhamnus alaternus* (layer 574).

From layer 569b, some fragments of fruit remains (at least in one case attributed to *Prunus* sp.) and cereal kernel tissues were recovered. Three Brassicaceae seeds (layer 569a) were identified as *Raphanus* sp. (Figure 11a-b), although it is not clear whether this species should be considered as a wild or introduced plant (see Gabr 2018, Fig. 2.4).

Figure 9. Hulled barley (*Hordeum vulgare*) caryopsis from Piano dei Cardoni (Photo credit: C. Speciale).

Local Vegetation Dynamics from the mid-eighteenth Century up to Present day According to Available Literary Sources

Describing Ustica as uninhabited, Amico Statella (1759) also reported that the island was home to scattered woodlands and pasturelands and hosted a number of feral goats. In the same years, Pigonati (1762) reported the occurrence of extensive nuclei of evergreen maquis dominated by 'wild' olives. Together with *Pistacia lentiscus* and two other small evergreen trees, *Phillyrea latifolia* and *Rhamnus alaternus*, large olives probably formed an almost continuous maquis on the flat coastal plains on both sides of the central ridge formed by the remnants of locally extinct volcanic cones. In contrast, the steepest slopes and the thinnest base-rich lithosols were probably dominated by the summer-deciduous *Euphorbia dendroidres*. According to Pigonati (1762), local olive trees were large enough to obtain good timber for carpenters and to be grafted for olive production. The availability of large woody plants from which to obtain timber is also reported in the map dated to 1770. Pigonati (1762) also mentions the occurrence of several temporary ponds, the so-called 'gorghi'; many of them had not yet been transformed by the local people, and would not be until the first half of the nineteenth century, as attested by the first maps (Figure 9), Smyth (1824), Gussone (1832-1834, 1842-1845) and Calcara (1842).

Several maps of the island were produced in the late 18[th] and early 19th centuries. Among them, the most interesting and informative are the (i) *Pianta dell'isola di Ustica* (by an anonymous author in 1770) (Figure 12a), and (ii) *Schizzo approssimativo dell'isola di Ustica* (by Giuseppe Malleo and stored into Archivio Mortillaro in 1852) (Figure 12b) (Barraco Picone 2008). The first one was found in the National Library of Naples and bears the following heading: 'Map of the Island of Ustica showing the new houses and other farms outlined in 1770'. This is the graphic documentation prepared by the Bourbon military engineers, accompanying the building project of the new inhabited centre and the defense provision for the island started with the colonisation of 1763. The captions of the map include very accurate information about the state of the site: the tree-lined and arable land, the road system crossing the localities Ogliastrello and Tramontana, the coves with the indication of the toponyms and their accessibility, the old buildings and the disused windmill. This map clearly points out that the largest flat surfaces of the island were rapidly deforested and rapidly turned into crop fields.

The second map is the first cadastrial map of the island. This document was drawn up in 1852 by the royal delegate Giuseppe Malleo and is featured within the regional land register ordered in 1810

Table 2. List of the archaeobotanical samples from the record of Faraglioni Village – year 2018

Context	*Olea europaea* wood	*Pistacia lentiscus* wood	*Rhamnus/ Phillyrea*	Unidentified wood	*Raphanus* sp.	*Phillyrea* seed	Unidentified cereal	Unidentified seeds
RA 148	5	/	/	/	/	/	/	/
RA 157	/	/	/	/	/	/	/	/
RA 165	7	/	/	/	/	/	/	2
RA 166	2	/	/	/	/	/	/	/
RA 175	9	/	/	1	/	/	/	1
US 569°	2	2	1	/	3	/	/	/
US 569b	/	/	/	/	/	/	3	/
US 574	6	/	1	3	/	2	/	/

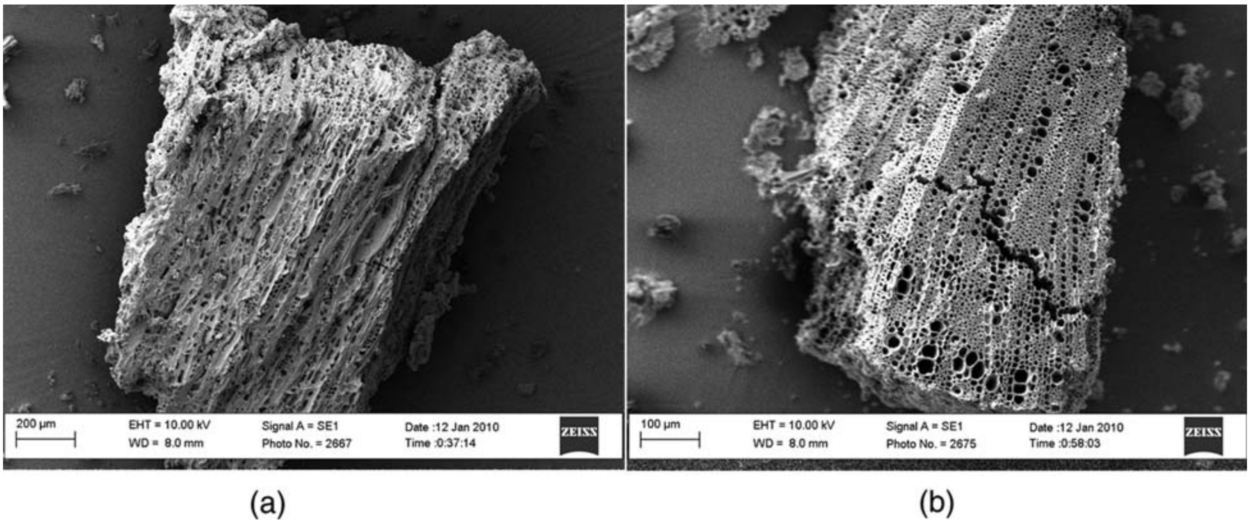

Figure 10. (a-b) Tangential and transversal section of olive tree (*Olea europaea* L. var. *europaea*) charcoal from Faraglioni Village (Photo credit: G.P. Di Sansebastiano).

Figure 11. Radish (*Raphanus* sp.) seeds from Faraglioni Village, layer 569a (photo credit: C. Speciale); for modern seeds' images from *Raphanus* spp. see e. g.: https://www.idseed.org/seedidguide/public/uploads/gallery_photo/resize_5ee0011a501d4.jpg.

by King Ferdinand II. This document contains accurate information on the road system, onthe arable land surfaces assigned to local settlers, on the number and the location of the 'gorghi' and on the areas devoted to other civic uses, such as pasturelands or area were wood harvest and logging activities were allowed (blue). Moreover, this map provides the exact location of vineyards (in locality Tramontana) and fruit tree/olive groves, mostly concentrated in the outskirts of the village and includes also the toponyms of the districts and the inlets of the coast.

The intensification of land use caused the rapid and complete destruction of local woody communities, which were cleared in order to produce charcoal and to free up land for arable fields and cultivated terraces, which were built with dry-stone retaining walls (Barbera et al. 2009). The crops included vines, flax, cotton, legumes, cereals and *Salsola kali* L., which was burnt to extract potassium (Calcara 1842; Giacino 2012; Gussone 1832-1834; Smyth 1824). In response to the worsening shortage of raw wood, crucially important also for the making of tools needed in the daily peasants' life (Sala et al. 2020), a few holm oaks (*Quercus ilex* L.) and ash-trees (*Fraxinus angustifolia* Vahl) were planted in the coolest part of the island, named 'Boschetto' by the local people. Interestingly, the last remnants of that planting experiment are still alive there two centuries later, enjoying the particularly shady and cool microclimatic conditions of the North-facing foothills of Monte Guardia.

The sudden deforestation triggered intense soil erosion and repeated disastrous floods, even leading to fatalities, as attested by Bonasera (1963) and

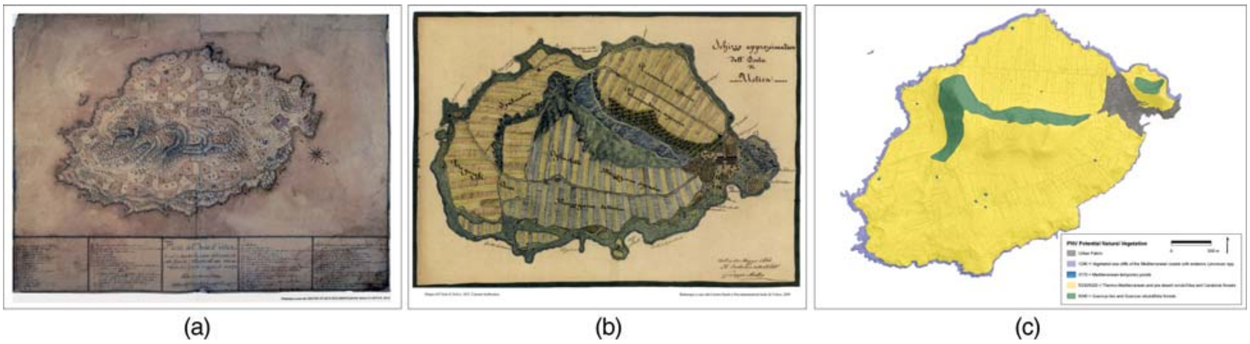

Figure 12. FIgure 12a: *Pianta dell'isola di Ustica* (by an anonymous author in 1770, National Library of Naples); Figure 12b: *Schizzo approssimativo dell'isola di Ustica* the first cadastrial map of the island (by G. Malleo, stored in Archivio Mortillaro in 1852, recently published by Centro Studi e Documentazione Isola di Ustica); Figure 12c: Vegetation map showing the potential wood cover at the moment of human arrival in the Neolithic (from AA. VV. 2009, modified).

Tranchina (1982). The severity of that ecological disaster sadly resembles the one that occurred between the 1840s and 1870s on the islands in the Strait of Sicily, especially Lampedusa (Pasta and La Mantia 2003).

After the Second World War, Ustica experienced an intensification of agricultural activities.

From the end of the 1960s, seasonal tourism gradually became the main source of income for the local community, inducing the gradual abandonment of traditional agro-pastoral practices. As a consequence of almost undisturbed progressive succession, most of the once cultivated terraced fields are nowadays covered by species-poor shrublands and/or mosaic-like grasslands dominated by perennial grasses like *Hyparrhenia hirta* (L.) Stapf and/or annual grasses like *Stipellula capensis* (Thunb.) Röser & H.R. Hamasha.

Discussion

This paper illustrates the initial results of the analysis of plant remains collected in two archaeological sites on the island of Ustica. As this first dataset takes into account a small sample size, different conclusions could be reached in the prosecution of the archaeological investigations. The intensity and the timing of the impact of the first human communities on the local landscape have still many open questions. Moreover, off-site paleoenvironmental datasets from the island are absent – 'gorghi', the seasonal ponds, are unfortunately not suitable for palynological analyses according to our first attempts.

In the bigger picture, Ustica and the relation between humans and vegetal resources during the Neolithic can be compared to some of the dynamics of opening landscape in the Balearic Islands (Burjachs, Pérez-Obiol, and Picornell-Gelabert 2017), despite the very reduced surface of Ustica, with its 8 sqm, make it a relatively fragile context in terms of woody cover with few comparisons in Mediterranean archaeobotanical literature during the 5th millennium BC.

However, the following data have all been recorded in Piano dei Cardoni archaeological site: the occurrence of farming activities (agriculture and animal husbandry); the exploitation of wild animal species (e.g. birds, fishes and land marine molluscs); the presence of many obsidian tools and associated processing activities; the coexistence of local and imported pottery; and the employment of specific volcanic raw materials (e.g. grinding stones) for processing cereals and pulses (Speciale et al. 2019, 2020, 2021, in press). Collectively, these activities may be assumed to have had a powerful impact on the pristine natural landscape of Ustica. The presence of at least two Middle/Late Neolithic sites on the island, whose location was apparently chosen not on the basis of military/defense criteria but for agricultural reasons, attests to the occupation of the whole island, albeit with low demographic density. These Neolithic communities undoubtedly exploited local woody resources, with scrub and maquis communities found almost everywhere and forest trees probably mostly concentrated on the higher ridges and the north-facing slopes of hills.

The Neolithic occurrence of dwarf palm is still unclear, but exploitation of their fruits and hearts should not be excluded, together with other uses as ethnobotanical comparison may suggest (Medjati et al. 2019).

Local climatic and topographic patterns and the floristic composition of last nuclei of maquis suggest that the pristine, unspoiled woody vegetation was dominated by high evergreen maquis (or even forest) communities. More in detail, as it has been illustrated in Figure 12c (from AA. VV. 2009, modified), associations like *Rhamno alaterni-Quercetum ilicis* and/or *Pistacio lentisci-Quercetum ilicis* (alliance *Quercion ilicis*) probably prevailed in the NW-, N- and NE-facing slopes of the main hills, whilst thermophilous sclerophyllous shrublands referred to the associations

Euphorbietum dendroidis, *Pistacio lentisci-Chamaeropetum humilis* (alliance *Oleo-Ceratonion*) covered the large majority of the island, i.e. the almost flat and warmer parts and the steeper S-facing slopes (Brullo et al. 2009). In these latter woody communities, at least during the Bronze Age, an important role was probably played by one or two evergreen Oleaceae, i.e. *Phillyrea latifolia* and/or *Olea europaea*. As for *Pinus* sp., there may have been *P. halepensis* Mill., which commonly co-occurs with *Pistacia lentiscus* in the Mediterranean basin. Moreover, the occurrence of *P. pinaster* Aiton should be discarded because the soils of Ustica are not sandy and acidic enough to favour the success of this species, and because of the total lack in the archaeobotanical record of commonly associated woody species such as heaths (*Erica* spp.), and brooms (Fabaceae tribe Genisteae).

The macro-remains from MBA Faraglioni Village consist almost exclusively of wood charcoals, almost all of which are of olive trees, with other local shrubs accounting for a very small proportion. The dominance of olive trees in the MBA record indicates a highly specific use of wood resources (maybe for fuel); curiously, there is no evidence of the forest cover found 3000 years earlier. On the other hand, *Olea europaea* is totally absent from the Neolithic record, despite the presence of other species from the Oleaceae family. Considered all together, the data from the two records suggest that the domestic variety of *Olea* was introduced to Ustica at some point before or in the MBA for its fruit, as seen in the Italian Peninsula in the same historical phase and elsewhere in Europe from the Copper Age onwards (Langgut et al. 2019; Stika, Heiss, and Zach 2008; Terral et al. 2004; Tinner et al. 2009). The fragments of domestic olive trees in Faraglioni also belong to small branches that may be the result of pruning and therefore another good proxy for active olive cultivation on the island. The seeds of *Raphanus* sp. may attest to its introduction as food and/or pesticide, or the plant may have simply occurred as a common weed in local cultivated fields. The Neolithic and Early Copper Age occupation together lasted about one thousand years (around 4700–3700 cal BC), probably enough to have affected the pristine vegetation cover. The abundant presence of ovicaprines in Piano dei Cardoni, together with cattle and pigs, attests to the practice of grazing, which may also have shaped the landscape and contributed significantly to the forest opening and degradation of Ustica (Rotherham 2013). However, it may also have induced to the establishment of a wood-pasture landscape that would have been sustainable despite the resource-limited environment for timber (Rackham 2013). Finally, deliberate fires may have been another factor of major disturbance for the natural tree cover (Noti et al. 2009; Tinner et al. 2009, 2016), but no archaeological evidence of such arsons was found so far on the island.

The material analysed so far did not show the occurrence of any hygrophilous plants, suggesting that local wetlands and temporary ponds covered small surfaces in the past like in modern times.

According to our first analyses, the wood cover of Ustica during the Neolithic was much denser than today, probably similar to the maquis-like vegetation found by the colonists of the mid-eighteenth century found on their arrival, as shown by the historical map of 1770 and the account written by Pigonati (1762). Comparing that map with the one of 1852, the speed and the intensity of deforestation appears striking. On the one hand, based on the available archaeobotanical data, it remains unclear whether the local woody vegetation had recovered during the period of reduced and discontinuous human presence from the end of the Copper Age to the MBA (mid-4th-beginning of 2nd millennium BC). On the other hand, the occurrence of olive trees during the Faraglioni phase definitely indicates the local exploitation of this species, which was absent or rare during the Neolithic.

As for agricultural practices, there is less evidence for the Neolithic phase, emmer wheat (*Triticum* cfr. *dicoccum*) and hulled barley (*Hordeum vulgare*) representing the earliest domestic cereal crop species recorded on the island. The huge number of querns, mortars and other volcanic stone tools, together with obsidian blades and bladelets, points to a consolidated local agricultural economy (Speciale et al. 2020, 2021).

For the MBA phase, the presence of kernels of domestic cereals (which were probably part of the diet of local villagers) and endocarps of unidentifiable fruits, together with the widespread presence of volcanic stone tools all over the village, attests to the reliance on agricultural resources and household-based processing (Spatafora 2016). The seeds of wild or domestic horseradish may also be linked to domestic consumption. In at least two of the pits, the presence of cereal kernels' fragments suggests the production of cereal-based foods.

Conclusions

A diachronic analysis of the evolution of the vegetation and landscape on a small volcanic island requires a multidisciplinary approach, taking account of the information provided by archaeologists, archaeobotanists, palaeoecologists, botanists and vegetation scientists. Despite the low demographic density during the Neolithic, human occupation had a significant impact on the vegetation patterns of Ustica, mainly due to the spread of agriculture and to the grazing/browsing activity by introduced herbivores. However, it was only during the MBA that these agro-pastoral activities appear to have become widespread and consolidated.

Ustica's current landscape patterns undoubtedly differ sharply with respect to the situation encountered by the first human colonisers during the Neolithic period. As literary sources and historical maps show, the local vegetation was radically transformed and re-shaped once again during the 18th and 19th centuries, when the local woody communities were almost completely destroyed and most of the island's suitable land was brought into cultivation. The profound transformation of the local landscape within the space of a few decades severely reduced the island's wood resources, probably already depleted by thousands of years of discontinuous human occupation. The opening of the landscape and the beginning of soil erosion processes started therefore since the first human occupation of the island, with some potential recovery during the phases of abandonment.

Our initial results suggest that holm oaks and stone pines were present at the moment of the first human colonisation (mid-5th millennium BC), whilst the introduction and exploitation of olive trees probably occurred during or prior to the second half of the 2nd millennium BC. The absence of *Olea europaea* in the Neolithic record points to the subsequent introduction of domesticated olive varieties, which may have been able to form a near-natural forest as a consequence of the succession processes taking place during the centuries-long abandonment from the late Middle Ages to the eighteenth century AD. In the end, historical mentions of oleaster, *Olea europaea* L. var. *sylvestris* (Mill.) Lehr., deserve to be confirmed, and the near-natural evergreen woodland nuclei observed by agronomists and naturalists during last centuries may have been dominated by fully naturalised olive trees issuing from introduced varieties.

Future analyses of archaeobotanical remains from the other prehistoric sites and from the Roman and Medieval occupation will probably help to clarify the landscape dynamics of Ustica across millennia of repeated occupation, agricultural exploitation and abandonment.

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