



A look at the region

The SUCCESSO-TERRA Project: a Lesson of Sustainability from the Terramare Culture, Middle Bronze Age of the Po Plain (Northern Italy)

Mauro Cremaschi^a, Anna Maria Mercuri^b, Alessandra Benatti^b, Giovanna Bosi^b, Filippo Brandolini^a, Eleonora Clò^b, Assunta Florenzano^b, Elisa Furia^b, Guido S. Mariani^a, Marta Mazzanti^b, Maria Chiara Montecchi^b, Eleonora Rattighieri^b, Rossella Rinaldi^b, Paola Torri^b, Andrea Zerboni^a

^aDipartimento di Scienze della Terra "A. Desio", Università degli Studi di Milano, Milano, Italy

^bLaboratorio di Palinologia e Paleobotanica, Dipartimento di Scienze della Vita, Università di Modena e Reggio Emilia, Modena, Italy

ARTICLE INFO

Article history:

Received: 29th December 2018

Accepted: 31st December 2018

Key words:

archaeology
climate change
Terramare
mid-Holocene
interdisciplinarity

ABSTRACT

This backstory article deals with the SUCCESSO-TERRA Project (2017–2020), an interdisciplinary research program aiming at reconstructing the land-use transformations that occurred during the development of the Terramare culture in the southern-central Po Plain of Northern Italy. Topics include climate-environment changes, human impact and exploitation of natural resources that are interconnected topics in human ecology and environmental sciences. These topics can only be understood in a long-term perspective integrating archaeology, geology, botany and other sciences. The text includes the theoretical basis, the research strategy and the main methodological approaches given by geoarchaeology and palynology, the two research sides constituting the partnership of the project.

1. Background

How can we mitigate the effects of climate change? How can our society develop towards models of sustainable development in the coming years? The “bridge” to sustainability is a pivotal topic of international debate and is among the priorities of the agenda of the Horizon2020 Societal Challenges, linking the past with the future. Despite the many achievements emerging from some new solutions, it is becoming increasingly aware that the study of the past is at the root of reliable and responsible actions for the future.

The SUCCESSO-TERRA Project (*Human societies, climate-environment changes and resource exploitation/sustainability in the Po Plain in the mid-Holocene: the Terramare culture*; 2017–2020) is an interdisciplinary research program aiming at reconstructing the landscape and land-use transformations that occurred during the

trajectory of the Terramare culture in the southern-central Po Plain of Northern Italy (Figure 1). The project, funded by

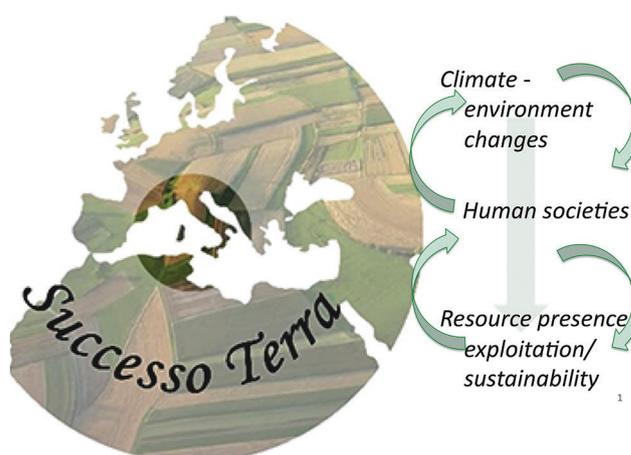


Figure 1. The logo and concept of the SUCCESSO-TERRA Project.

*Corresponding author. E-mail: annamaria.mercuri@unimore.it

MIUR (Ministry of Italy for University and Research, action 20158KBLNB, P.I.: M. Cremaschi) joins together experts on Geoarchaeology (University of Milan) and Palynology (University of Modena and Reggio Emilia) to study high-resolution archaeological sediments with an interdisciplinary ecological perspective.

SUCCESSO-TERRA points towards the relationships between climate-environment changes, human impact, and exploitation of natural resources – topics that are traditionally interconnected in human ecology (Butzer, 1982). These topics can only be understood given a long-term perspective: integrating archaeology, geology, and biology (mostly consisting of botany and zoology). The concept that archaeological sciences can be a tool to deal with modern societal challenges is at the basis of SUCCESSO-TERRA: an “old but new approach” to compare current issues to those concerning sustainability in the 3rd millennium BP.

Archaeological scientific investigations with a long-term perspective have repeatedly suggested a possible nexus between changes in climate (main trends and rapid events) and societal crises during the Holocene (Jalut *et al.*, 2009; Mercuri *et al.*, 2011); the main role played today by the on-going climate change in influencing human adaptation is also evident (Oldfield, 2005; Mercuri *et al.*, 2015a). To establish if climate change influenced the cultural trajectory of the Terramare culture – and if so, then to estimate its true contribution – is the core of the project. The Terramare settlements are exemplar archaeological/palaeoenvironmental contexts showing the complex dynamic between regional climatic/environmental changes and land use.

SUCCESSO-TERRA avoids climatic determinism and maintains a bi-directional perspective in the study of the relationships between climate, environment, and people – considering as it does the environment and civilizations as part of a complex dynamic system (*e.g.* Stoffle *et al.*, 2003; Mercuri, 2008; Cremaschi, Zerboni 2009; 2011; Mercuri, Sadori, 2012). From one side, climate changes have triggered environmental and cultural adaptations. From the other side, people have continuously, and deeply, shaped the landscape in which they settled. However, a continuing and increasing human exploitation of natural resources creates an imbalance in the system (Diamond, 2005), resulting in possible episodes of population relocation or the collapse of human societies. Within this framework, Bronze Age Mediterranean civilizations have offered us several examples of crises with catastrophic outcomes. Similar dramatic effects have been recorded along the Alpine fringe with the crisis of the pile-dwelling communities (Magny *et al.*, 2011). All these episodes led to significant changes in the structure of the involved civilization that, experiencing as they were the first steps of urban culture at that time, had an unsustainable impact on the environment.

Interdisciplinary research is mandatory if we want to understand the adaptive strategies of civilizations at different times and within a long-term perspective (Mercuri and Florenzano, 2019). The Terramare case study refers to

the changing environment during the Middle and Recent Bronze Ages (ca. 1550–1170 years BC; Bernabò Brea *et al.*, 1997; Mercuri *et al.*, 2006a), at the Middle to Late Holocene transition, and at the border between continental and Mediterranean Italy.

2. The Terramare narrative based on archaeological and scientific evidence

The term Terramare indicates the banked and moated villages of the Bronze Age, located in the alluvial plain of the Po River of Northern Italy, mostly in present-day Emilia Romagna (Pearce, 1998; Bernabò Brea, Cremaschi, 2009; Cremaschi, 2013). The Terramare culture flourished in the central part of the Po Plain during a period spanning the 16th to the 12th century BC. The Terramare economy was based upon farming, herding, and metallurgy (Bernabò Brea *et al.*, 1997); moreover, Terramare settlements relied on having a well-developed management of water and wood resources. The people settled in an open environment that hosted scattered woodland and plentiful water resources. The Terramare people promoted networks of commercial exchange between northern Europe and the Mediterranean region. This civilization lasted for approximately 500 years, before suddenly collapsing around 1150 BC (Cardarelli, 2009).

Extensive excavations and geophysical surveying disclosed the complexity of their settlements and the interconnections between residential areas, defensive structures, fields and the natural hydrography. Agriculture in fields was supplied with irrigated water, and an innovative and sophisticated management system of the natural hydrographic network was developed (Cremaschi, 2009). Large artificial canals were excavated to draw water from rivers to the moats surrounding villages; then, water was redistributed to the fields through a dense network of irrigation ditches (Cremaschi, Pizzi, 2007; 2011; Cremaschi, 2018). The irrigation strategy and competent agriculture triggered this skilled civilization to its apogee with a demographic increase from the Middle to the Recent Bronze Age. Mesophilous woods (oaks and hornbeams) gave a major supply of natural raw material for building, fuel, and food (Cardarelli, 2009; Cremaschi, 2010; Mercuri *et al.*, 2006a; 2015b). Pollen diagrams show low forest cover close to sites with a significant presence of wet environments and a set of anthropogenic habitats testified by pollen indicators of crops and synanthropics (API, as described by Behre, 1981; Mercuri *et al.*, 2013).

According to the palynological record, the agricultural economy was based on forest management including coppicing, fruit collection in the wild, and crop fields. The fields included different types of cereals (Ravazzi *et al.*, 1992; 2004; Mercuri *et al.*, 2015b; Cremaschi *et al.*, 2016) with evidence of intercropping with legumes (Mercuri *et al.*, 2006a; 2006b). Moreover, most of the open landscapes around the villages were used for pastures as suggested mainly by Cichorieae and other pasture pollen indicators

(Ravazzi *et al.*, 2004; Mercuri *et al.*, 2006b; 2015b; Cremaschi *et al.*, 2016). These land-use types have also been confirmed by the recovery of well-preserved macrobotanical remains in most of the studied contexts (Rottoli, Motella, 2004; Rottoli Castiglioni, 2009).

The intensification of the food demand probably caused cereal production to be inadequate for such a high number of people. Environmental stresses became ever more evident and wood resources were renewing slowly. For instance, the last phases of the pollen diagram from the Terramara di Montale show a decrease of woodland together with a reduction in cereal fields suggesting that soil and wood overexploitation might have been among the actual causes of the Terramare's crisis (Mercuri *et al.*, 2006b). At the top of the sequence of Santa Rosa di Poviglio, in correspondence with the drying of the moat system, a similar dramatic decrease of woods suggests that there may have been a twofold causation in the societal crisis affecting the Terramare culture: the increased aridity (a natural factor) and the overgrazing of natural resources (an anthropogenic factor) might have played a fairly synchronous action on the landscape (Cremaschi *et al.*, 2016). The societal collapse of the Terramare culture is dated at ca. 1150 years BC; settlements in the central Po Plain were abandoned and Final Bronze Age settlements survived only in the northern sector of the Po Plain and in the Northern Apennines.

3. Research strategy

3.1 Key archaeological sites

The SUCCESSO-TERRA Project analyses data from three Bronze Age sites (Figure 2): (i) the Terramara Santa Rosa di Poviglio (Bernabò Brea, Cremaschi, 2004) (Figures 3–5) and (ii) the Vasca di Noceto site (Bernabò Brea, Cremaschi,

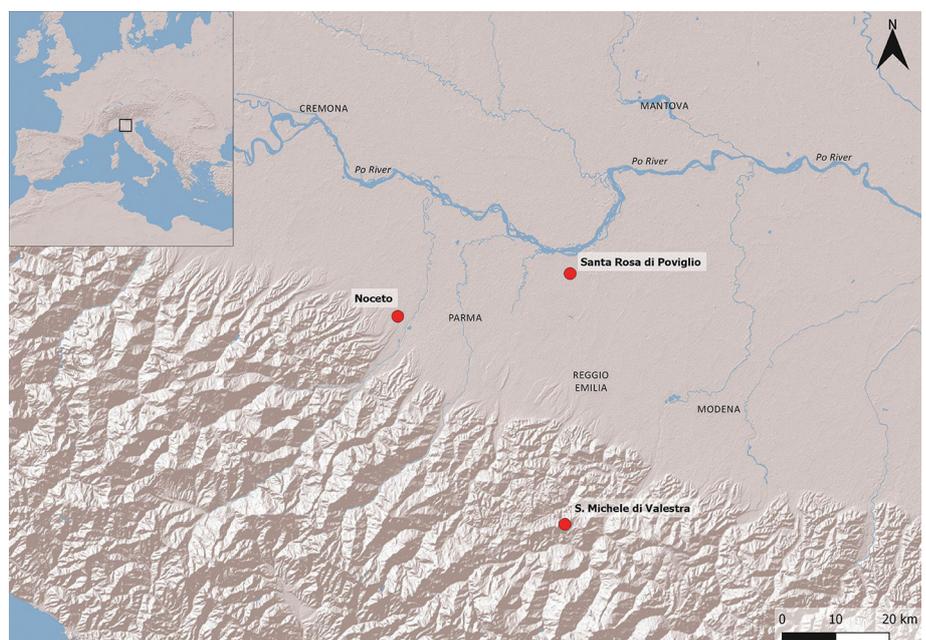
2009) (Figures 3, 6–8) are in the Po Plain; while (iii) the San Michele di Valestra (Cremaschi, 1997) site is a coeval settlement in the Apennines (Figures 3, 9–10). The first and second sites are well-known archaeological sites belonging to the Po Plain Terramare culture, whose excavations have been on-going for many years. The latter – San Michele di Valestra – is a Bronze Age site, located outside the Terramare territory, but in the adjoining Apennine range. This site survived the Terramare crisis and was settled with continuity throughout the Middle, Recent, and Final Bronze Ages, up to the Iron Age.

The methodology of the project is interdisciplinary; it is mainly based on geoarchaeological and archaeobotanical (pollen and macroremains) investigations. The main actions are on-going: to carry out archaeological excavations in the key sites, and a regional survey in areas surrounding the main archaeological settlements.

3.2 Geoarchaeology

Geoarchaeological investigations at selected sites are on-going, the main aim being to understand the human and natural contributions to the development and abandonment of the Terramare settlements in the Po Plain. Since the beginning of research into the Terramare in the nineteenth century, it has been clear that the moats surrounding these sites were connected to adjoining rivers from which water was obtained by canals (Pearce, 1998; Cremaschi, 2013). Additionally, the moats were fed by artesian wells excavated within the limits of each settlement (Cremaschi *et al.*, 2006; 2016). At the Santa Rosa di Poviglio site (Figures 3–5), for instance, all these hydrological structures date back to the late Middle Bronze Age and, along with the infrastructure and residential buildings, are part of the urban planning project. Many large water wells had been opened along the edge of the settlement after the Middle Bronze Age and they

Figure 2. Map of the central sector of the Po Plain of Northern Italy indicating the sites investigated in the SUCCESSO-TERRA Project.



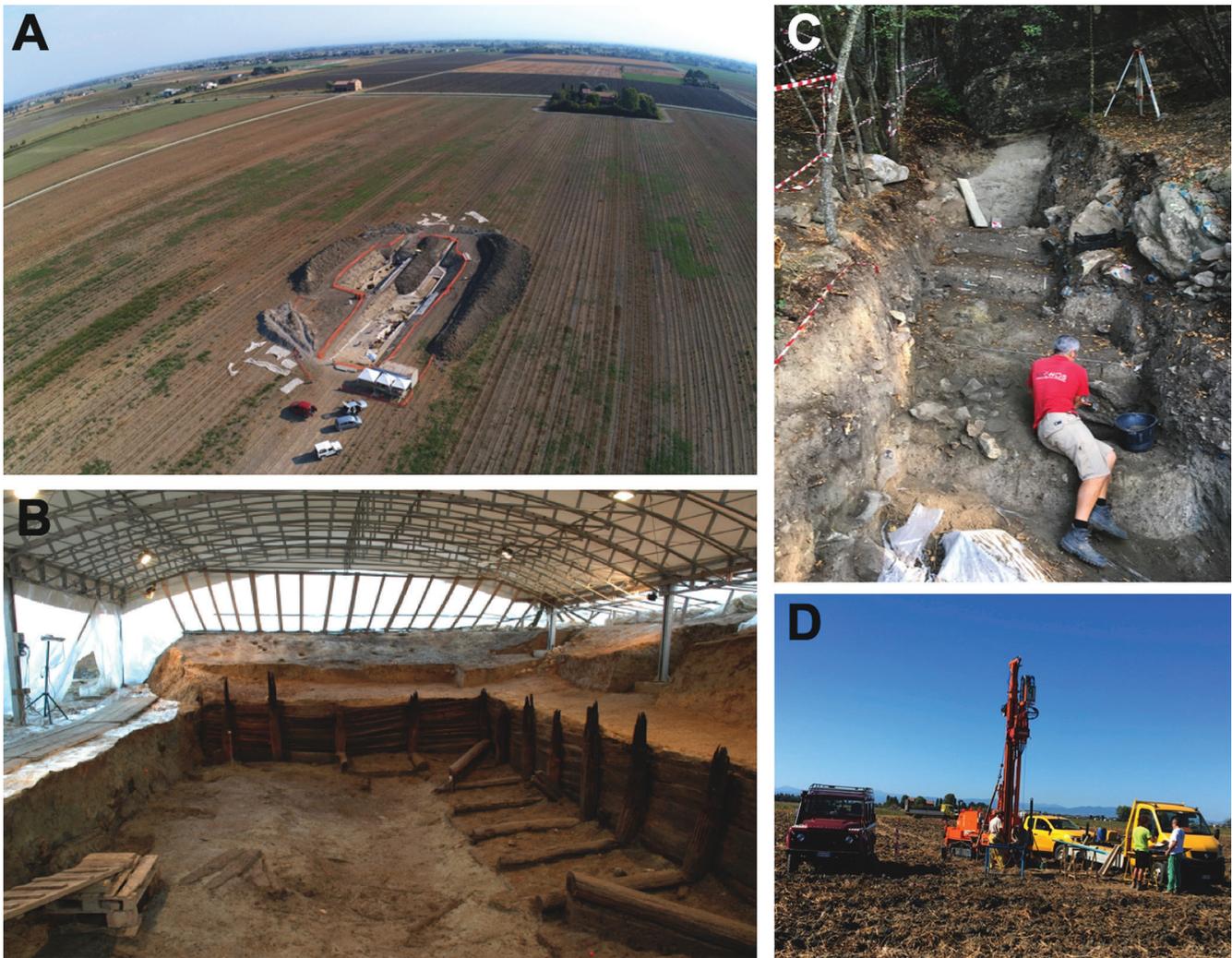


Figure 3. Pictures of the investigated sites: A) oblique aerial view of the Terramara Santa Rosa di Poviglio; B) the Vasca di Noceto site; C) the stratigraphic sequence of the San Michele di Valestra site; D) coring in the vicinity of the Terramara Santa Rosa di Poviglio.



Figure 4. Oblique aerial view of the excavation of the moat of the Terramara Santa Rosa di Poviglio; note the alignments of postholes and several water wells.

Figure 5. Excavation of the moat of the Terramara Santa Rosa di Poviglio.



Figure 6. A detail of the wooden structure of the Vasca di Noceto site (from Bernabò Brea, Cremaschi, 2009).



had been re-excavated several times. The wells exploited the sandy aquifers (at 2 to 3 m of depth), and several ditches conveyed water, not to the interior of the village, but to the moat (Cremaschi, 2013). The excavation of the Santa Rosa di Poviglio site thus illustrates that wells went out of use and silted up in the Final Bronze Age; as a consequence, the moat was also deprived of water and silted up (Cremaschi *et al.*, 2016).

Natural archives of proxy data have been selected in order to gather further data and explain the reasons and timing of the environmental crisis determining the lowering of the water table in the region and the subsequent reduction in water reservoirs (Cremaschi *et al.*, 2016). We collected several sediments cores in the vicinity of the Terramara Santa Rosa to investigate the local dynamic of the alluvial plain

(Figure 3) and sampled a speleothem from the Tana della Mussina Cave in the Apennines, representing a very well preserved local archive of changes in Mid-Late Holocene rainfall. Moreover, geoarchaeological excavations at the San Michele di Valestra site (Figures 3, 9–10) will elucidate the key factors that enabled the higher resilience of the Bronze Age groups living in the Apennine ranges which survived the environmental crisis.

3.3 Palynology

Pollen samples were collected from trenches excavated in the main archaeological structures of the selected sites: (i) the moat and ditch surrounding the Santa Rosa di Poviglio site; (ii) the infilling of the Vasca Grande di Noceto; and (iii) a trench cutting the occupation layers of



Figure 7. A ritual deposition of pottery and wood tools within the Vasca di Noceto site (from Bernabò Brea, Cremaschi, 2009).



Figure 8. A detail of the sedimentary infilling of the Vasca di Noceto; note the thinly laminated deposits formed by decantation (from Cremaschi *et al.*, 2009).

the S. Michele di Valestra site. Moreover, three offsite cores have been extracted in the area surrounding the Terramare Santa Rosa di Poviglio. The sampling strategy covers on-site/off-site integrated records that are useful to distinguish human pressure and impact at both a very local and regional scale (Mercuri, 2014).

Besides the basic treatments, the pollen extraction has included sieving and heavy liquid floatation to concentrate microscopic remains: this is mandatory to obtain good pollen content from the archaeological layers (Florenzano *et al.*, 2012). Pollen, non-pollen palynomorphs (algae, fungi, animal fragments) and microcharcoal particles help to reconstruct the flora composition, vegetation dynamics

and palaeoecology. A set of anthropogenic pollen indicators (common in the spectra from Italian archaeological sites; Mercuri *et al.*, 2013) may be especially useful to reconstruct the agricultural dynamics, besides the distribution of wild vegetation (wood and wetland plant associations). The palynological research allowed details of some of the complex processes in the agricultural economy to be filled in, such as were practiced on the basis of wood management and crop fields.

Since the first attempt of reconstructing the ancient land use, it appears evident that the area of influence of each Terramare settlement was a complex mosaic of natural and human-controlled landscapes; however, new results point to

some local differences in the availability and exploitation of wood and water resources at each archaeological site. As a general rule, the pattern was of cereal and legume fields that were alternated to pastures. Trees had a strategic role at Poviglio, Baggiovara, and Casinalbo. The large availability of water furthered the spread of hygrophilous woods near rivers, but oak woodland with oaks and hornbeam were also cared for. The Terramare people were aware of the importance of natural resources, and used the oak-woodland trees for collecting fruits, feeding animals, and making tools. We found signs that they maintained their oak woodlands by coppicing for hundreds of years, at least up until the time, when environmental stresses still allowed their cultural knowledge to survive in these lands.

4. General remarks and perspectives

For the first time, the SUCCESSO-TERRA Project offers to fully investigate the complex environmental and human nexus in the Bronze Age of the Po Plain, shining new light on the mutual interconnection between climate change, land-use, and human resilience. Our interdisciplinary approach will disclose the natural (aridification) and anthropic (overexploitation) reasons for the collapse of the Terramare culture in the Po Plain, and why in mountain areas coeval communities displayed a higher resilience to incoming climatic changes.

Follow the SUCCESSO-TERRA project: <https://www.successoterra.net>



Figure 9. Excavation of the San Michele di Valestra site; view of a rock shelter buried and filled by the archaeological stratigraphy.

Figure 10. Stratigraphic section of the excavation of the San Michele di Valestra site.



Acknowledgements

The SUCCESSO-TERRA Project is financed by the Italian Ministry of Education, University and Research (MIUR),

grant PRIN20158KBLNB (P.I. M. Cremaschi). Further support to the excavation of the Terramara S. Rosa di Poviglio is from the University of Milano (Fondi Speciali per le Ricerche Archeologiche) and the municipality of Poviglio

(to M. Cremaschi). Further support to the excavation and conservation of the Noceto site is from the Italian Ministry of Cultural Heritage (MIBAC) and the municipality of Noceto (to M. Cremaschi). Part of this study is supported by the Italian Ministry of Education, University and Research (MIUR) through the project “Dipartimenti di Eccellenza 2018–2022” awarded to the Dipartimento di Scienze della Terra “A. Desio” of the University of Milano. The ongoing palynological research on cores near the Terramara di Poviglio is part of the PhD project of EC at the University of Modena and Reggio Emilia. AF, AZ, AMM, and MC wrote the paper; all authors are contributing to analytical and research phases of the SUCCESSO-TERRA Project.

References

- BEHRE, K.E., 1981. The interpretation of anthropogenic indicators in pollen diagrams. *Pollen et Spores*, 23, 225–245.
- BERNABÒ BREA, M., and CREMASCHI, M., 2004. *Il Villaggio Piccolo della Terramara di Santa Rosa di Poviglio: scavi 1987–1992*. Origines. Firenze: Istituto Italiano di Preistoria e Protostoria.
- BERNABÒ BREA, M., and CREMASCHI, M., 2009. *Acqua e civiltà nelle Terramare: La vasca votiva di Noceto*. Milano: Skira.
- BERNABÒ BREA, M., CARDARELLI, A., and CREMASCHI, M., 1997. *Le Terramare, la più antica civiltà padana*. Milano: Electa.
- BUTZER, K., 1982. *Archaeology as Human Ecology: Method and Theory for a Contextual Approach*. Cambridge: Cambridge University Press.
- CARDARELLI, A., 2009. Insediamenti dell'età del bronzo fra Secchia e Reno. Formazione, affermazione e collasso delle terramare. In: A. Cardarelli, L. Malnati, eds. *Atlante dei Beni Archeologici della Provincia di Modena (III): Collina e Alta Pianura*. Firenze: Edizioni all'Insegna del Giglio, pp. 33–58.
- CREMASCHI, M., 1997. Il sito d'altura di S. Michele di Valestra (RE). In: M. Bernabò Brea, A. Cardarelli, M. Cremaschi, eds. *Le terramare, la più antica civiltà padana*. Milano: Electa, pp. 285–286.
- CREMASCHI, M., 2009. Foreste, terre coltivate ed acque, l'originalità del progetto terramaricolo. In: M. Bernabò Brea, M. Cremaschi, eds. *Acqua e civiltà nelle Terramare: La vasca votiva di Noceto*. Milano: Skira, pp. 34–42.
- CREMASCHI, M., 2010. Ambiente, clima ed uso del suolo nella crisi della cultura delle Terramare. *Scienze dell'Antichità*, 15, 521–534.
- CREMASCHI, M., 2013. Terramara Santa Rosa di Poviglio Alluvial Site. In: C. Smith, ed. *Encyclopedia of Global Archaeology*. Berlin/Heidelberg: Springer Science.
- CREMASCHI, M., 2018. Settlements, Crops, Woods. Land use and resources in a changing environment at the time of the Terramare (XVI–XII century BC, N Italy). In: A. Florenzano, M.C. Montecchi, R. Rinaldi, eds. *CEA2018 Abstracts book. Humans and environmental sustainability: Lessons from the past ecosystems of Europe and Northern Africa, Modena, February 2018*. Abstract e-book, pp. 2–7.
- CREMASCHI, M., and PIZZI, C., 2007. I pozzi al margine del Villaggio Grande della Terramara di Santa Rosa di Poviglio (RE). Uso delle risorse idriche tra la fine del Bronzo Medio e il Bronzo Recente. In: A. Cardarelli, ed. *Studi in onore di Renato Peroni*. Firenze: All'insegna del Giglio, pp. 117–128.
- CREMASCHI, M., and PIZZI, C., 2011. Exploiting Water Resource in the Bronze Age Villages (Terramare) of the Po Plain (Northern Italy). Recent Investigation in the Terramara Santa Rosa of Poviglio. *Antiquity Project Gallery*, 85(327).
- CREMASCHI, M., and ZERBONI, A., 2009. Early to middle Holocene landscape exploitation in a drying environment: two case studies compared from the central Sahara (SW Fezzan, Libya). *Comptes Rendus Géoscience*, 341, 689–702.
- CREMASCHI, M., and ZERBONI, A., 2011. Human communities in a drying landscape. Holocene climate change and cultural response in the central Sahara. In: I.P. Martini, W. Chesworth, eds. *Landscape and Societies, Selected cases*. Springer Science, pp. 67–89.
- CREMASCHI, M., MERCURI, A.M., TORRI, P., FLORENZANO, A., PIZZI, C., MARCHESINI, M., and ZERBONI, A., 2016. Climate change versus land management in the Po Plain (Northern Italy) during the Bronze Age: New insights from the VP/VG sequence of the Terramara Santa Rosa di Poviglio. *Quaternary Science Reviews*, 136, 153–172.
- CREMASCHI, M., PIZZI, C., and VALSECCHI, V., 2006. Water management and land use in the terramare and a possible climatic co-factor in their collapse: the case study of the terramara S. Rosa (Northern Italy). *Quaternary International*, 151, 87–98.
- CREMASCHI, M., FERRARI, P., SALVIONI, M., and ZERBONI, A., 2009. Il riempimento della vasca e della fossa. In: M. Bernabò Brea, and M. Cremaschi, eds. *Acqua e Civiltà nelle Terramare. La vasca votiva di Noceto*. Milano: Università degli Studi di Milano and Skirà, pp. 112–120.
- DIAMOND, J., 2005. *Collapse: how societies choose to fail or succeed*. New York: Viking Books.
- FLORENZANO, A., MERCURI, A.M., PEDERZOLI, A., TORRI, P., BOSI, G., OLMÍ, L., RINALDI, R., and BANDINI MAZZANTI, M., 2012. The significance of intestinal parasite remains in pollen samples from Medieval pits in the Piazza Garibaldi di Parma, Emilia Romagna, Northern Italy. *Geoarchaeology*, 27, 34–47.
- JALUT, G., DEDOUBATA, J.J., FONTUGNE, M., and OTTO, T., 2009. Holocene circum-Mediterranean vegetation changes: climate forcing and human impact. *Quaternary International*, 200, 4–18.
- MAGNY, M., PEYRON, O., SADORI, L., ORTU, E., ZANCHETTA, G., VANNIÈRE, B., and TINNER, W., 2011. Changements dans la saisonnalité des précipitations en Méditerranée centrale au cours de l'Holocène. Implications pour l'histoire des sociétés. In: F. Bertonecello, F. Braemer, eds. *Variabilités environnementales, mutations sociales: natures, intensités, échelles et temporalités des changements. XXXIIes rencontres internationales d'archéologie et d'histoire d'Antibes*. Antibes: Editions APDCA, pp. 17–26.
- MERCURI, A.M., 2008. Plant exploitation and ethnopalynological evidence from the Wadi Teshuinat area (Tadrart Acacus, Libyan Sahara). *Journal of Archaeological Science*, 35(1), 619–642.
- MERCURI, A.M., 2014. Genesis and evolution of the cultural landscape in central Mediterranean: the “where, when and how” through the palynological approach. *Landscape Ecology*, 29, 1799–1810.
- MERCURI, A.M., and FLORENZANO, A., 2019. The Long-Term perspective of human impact on landscape for Environmental Change (LoTEC) and Sustainability: from botany to the interdisciplinary approach. *Sustainability*, 11, 413.
- MERCURI, A.M., and SADORI, L., 2012. Climate changes and human settlements since the Bronze age period in central Italy. *Rendiconti Online Società Geologica Italiana*, 18, 32–34.
- MERCURI, A.M., ACCORSI, C.A., BANDINI MAZZANTI, M., BOSI, G., CARDARELLI, A., LABATE, D., MARCHESINI, M., and TREVISAN GRANDI, G., 2006a. Economy and environment of Bronze Age settlements – Terramaras – on the Po Plain (Northern Italy): first results from the archaeobotanical research at the Terramara di Montale. *Vegetation History and Archaeobotany*, 16, 43–60.
- MERCURI, A.M., ACCORSI, C.A., BANDINI MAZZANTI, M., BOSI, G., TREVISAN GRANDI, G., CARDARELLI, A., LABATE, OLMÍ, L., and TORRI, P., 2006b. Cereal fields from the Middle–Recent Bronze Age, as found in the Terramara di Montale, in the Po Plain (Emilia Romagna, Northern Italy), based on pollen, seeds/fruits and microcharcoals. In: J.P. Morel, J. Tresseras Juan, J.C. Matamala, eds. *The Archaeology of Crop Fields and Gardens*. Bari: Edipuglia, pp. 251–270.
- MERCURI, A.M., SADORI, L., and UZQUIAMO OLLERO, P., 2011. Mediterranean and north-African cultural adaptations to mid-Holocene environmental and climatic changes. *The Holocene*, 21(1), 189–206.
- MERCURI, A.M., BANDINI MAZZANTI, M., FLORENZANO, A., MONTECCHI, M.C., RATTIGHIERI, E., and TORRI, P., 2013. Anthropogenic Pollen Indicators (API) from archaeological sites as local evidence of human-induced environments in the Italian peninsula. *Annali di Botanica (Roma)*, 3, 143–153.
- MERCURI, A.M., MARGINANI, M., and SADORI, L., 2015a. Palaeoecology and long-term human impact in plant biology. *Plant Biosystems*, 149, 136–143.
- MERCURI, A.M., MONTECCHI, M.C., PELLACANI, G., FLORENZANO, A., RATTIGHIERI, E., and CARDARELLI, A.,

- 2015b. Environment, human impact and the role of trees on the Po plain during the middle and recent Bronze Age: pollen evidence from the local influence of the terramare of Baggiovara and Casinalbo. *Review of Palaeobotany and Palynology*, 218, 231–249.
- OLDFIELD F., 2005. *Environmental change: key issues and alternative approaches*. Cambridge: University Press Cambridge.
- PEARCE, M., 1998. New research on the terramare of northern Italy. *Antiquity*, 72, 743–6.
- RAVAZZI, C., CREMASCHI, M., and FORLANI, L., 1992. Ricostruzione della storia vegetazionale padana tra l'età del Bronzo e l'alto Medioevo in relazione all'intervento antropico. La successione pollinica del fossato della terramara di Poviglio (R.E.). *Archivio Botanico Italiano*, 67, 198–220.
- RAVAZZI, C., CREMASCHI, M., and FORLANI, L., 2004. Studio archeobotanico della terramara S. Rosa di Poviglio (R.E.). Nuovi dati e analisi floristica e sintassonomica della vegetazione nell'età del Bronzo. In: M. Bernabò Brea, M. Cremaschi, eds. *Gli scavi nell'abitato piccolo della terramara di Santa Rosa di Poviglio (Reggio Emilia)*. Firenze: All'insegna del Giglio, pp. 703–735.
- ROTTOLI, M., CASTIGLIONI, E., 2009. Indagini sui resti vegetali macroscopici. In: M. Bernabò Brea, M. Cremaschi, eds. *Acqua e civiltà nelle terramare: La vasca votiva di Noceto*. Milano: Skira, pp. 152–163.
- ROTTOLI, M., MOTELLA, S., 2004. I resti antracologici e lignei della terramara Santa Rosa di Poviglio. In: M. Bernabò Brea, M. Cremaschi, eds. *Il Villaggio Piccolo della Terramara di Santa Rosa di Poviglio Scavi 1987–1992*. Origines. Firenze: Istituto Italiano di Preistoria e Protostoria, pp. 737–742.
- STOFFLE, R.W., TOUPAL, R.S., and ZEDEÑO, M.N., 2003. Landscape, nature, and culture: a diachronic model of human–nature adaptations. In: H. Selin, ed. *Nature. Across Cultures: Views of Nature and the Environment in Non-Western Cultures*. Dordrecht: Kluwer Academic Publishers, pp. 97–114.