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EDITORIAL
TO NOTES

2013 PALYNOLOGY: THE BRIDGE BETWEEN PALAEOECOLOGY AND ECOLOGY FOR THE UNDERSTANDING OF HUMAN-INDUCED GLOBAL CHANGES IN THE MEDITERRANEAN AREA

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Palynology as a bridge between palaeoecology and ecology

The starting point of palynology when dealing with ecology is that 'ecosystems are dynamic and have a history' (Willis & Birks, 2006; Birks, 2012).
In a thematic review centred on 'Cultural landscapes of the past', recently published, Mercuri, et al. (2010) outlined the essential role of botanists in creating a bridge of knowledge between past and present vegetation and human impact dynamics. This is especially obtained by providing a faithful interpretation of the plant cover developed as a consequence of presence or pressure of both past and modern human activities. These concepts match the assumptions of history as 'change with time' and 'ecology as a historical discipline' by Boero (2010).
Palynology, joint to archaeobotany, is more and more evidencing that human exploitation of wild resources produced a change of the environment in a landscape system at least since the early Holocene, approximately during the last eleven thousands years. In most of the Mediterranean, and especially in Italy, this was particularly evident since the Bronze age (Sadori & Giardini, 2008; Mercuri & Sadori, 2012; Mercuri et al., 2012). The historical biological sciences make us aware that the world in which we live today is less 'natural' of what we think (Mercuri & Sadori, 2013).

From habitat and knowledge fragmentations to the motivation for a holistic science

There are scientific problems, and there are research fields that help to solve them. A speciality discipline is by definition the tool every research needs to study a specific (speciality) part of the issue. The credibility of science is not likely to be achieved without solid disciplinary bases (Wu, 2006). While it may provide the highest level of information available in one part, it however provides in each research field a partial vision of the whole. This corresponds to the assumption that "a holistic view is greater than the sum of the specialized views that contribute to it" (e.g., Phillips, 1976; Haynes, 2009). Far from being an error, the intrinsic feature of each field of research suggests that the only way to correctly solve problems in science is the cooperative work of experts in different disciplines.
The current fashion in both research and teaching of biological sciences is the opposite. There is an evident success of the intrinsically specialty molecular approaches that parallels the fairly synchronous decline of intrinsically holistic environmental approaches. The separation of branches in current knowledge has the top expression in the European Research Council domains (PE, SH, LS) that are sub-divided in panels. This modern 'taxonomy of knowledge' applied to the topics of scientific research has created a

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somewhat mixed record of *relevance* and *competence* of arbitrary reference fields. For example, the panel SH6 1 ('Archaeology, archaeometry, landscape archaeology') states that 'landscape' deals with archaeological competence, and that botanists who work on landscape onset and evolution under natural and anthropogenic forces work in the field of archaeology and operate out of the Life Sciences relevance. Similarly, 'Environment, resources and sustainability' (SH3 1) and 'Environmental change and society' (SH3 2) are only in the domain of Social Sciences and Humanities.

Although the reasons of including 'climate change' in the panel PE10 3 may be understood, it is quite difficult to understand why the botanists who work on effects of climate on vegetation , and *vice versa*, are working out of the Life Sciences. In fact, 'Terrestrial ecology, land cover change' (PE10 4), and 'Paleoclimatology, paleoecology ' (PE10 6) are only included in the Physical Sciences and Engineering. Does this mean that botanists must not continue to study geobotany and vegetation history? Should they continue to study the adaptations of plants to climate changes in a diachronical perspective, the history of plant exploitation, the anthropisation and its effects on modern landscapes, or the land uses and transformations of plant cover under natural and cultural forces?

A well known effect of human action on the environment is the *habitat fragmentation*, the process by which habitat loss results in the division of large, continuous habitats into smaller, more isolated remnants (Didham, 2010). Habitat fragmentation is integrally intertwined with land use intensification (Bajocco et al., 2012). Both cultural landscapes and culture in general are products of human action. Thus, there is no surprise that the human action on culture has produced a *knowledge fragmentation*, an effect similar to the fragmentation made on the environment. But if we look at the history of culture, knowledge has continuously been approached from a holistic perspective. Hunter-gatherers acted as part of ecosystems and deeply knew natural diversity. The classical world and subsequent thoughts combined naturalistic and philosophical discoveries, and the fields of knowledge 'put together' evidences and theories available from scientists and philosophers. Heterogeneity is an essential cause and consequence of diversity and complexity in both natural and social systems (Wu, 2006), and this makes the disciplinary rigid partition simplistic. Nowadays, there is so great distance between the different specialized sciences used in research that the integration and interdisciplinary approach is more and more a must in environmental and human sciences (Blasi et al., 2008). Interdisciplinarity is frequently chased or declared, but less frequently convincingly performed.

The interdisciplinarity within botanical fields

The importance of combining palaeoecology, archaeology and history to understand cultural landscape development is well known. But why archaeologists ask for geologists, anthropologists, chemists, zoologists and botanists, while biologists so rarely ask for an integration of their different specialties? One can reply that the problems posed are different. The investigation on flora and taxonomy may run on a level of knowledge that frequently parallels the levels of other biological sciences. However, there are fields where questions are similar, and the integration is at the base of the progress of science.

This is the case of the 'science of land-change' (Rindfuss et al., 2004), a critical component of sustainability science which focuses on land use and land cover changes, within the dynamic interactions between nature and society. This is also the case of ecology dealing with past and current vegetation history and landscape development. Palaeoecology and modern ecology are very similar in questions, but separated by a different timescale.

Altogether, they may be theoretically part of the 'Long-Term Ecology'. This is a research field with network groups and several laboratories in the world (e.g., ILTER; LTER network by the National Science Foundation-USA; LTERN in Australia; LTER Europe: www.lter-europe.net; OxLEL in Oxford). In Italy, the CONECOFOR-Controllo degli Ecosistemi Forestali, established by the National Forest Service (Corpo Forestale dello Stato), is a technical police body involved in the monitoring of forest ecosystems. Since 2004, CONECOFOR covered the Italian partnership within the "ALTER-Net, A Long Term biodiversity, Ecosystem and awareness Research NETwork" (funded by the EU 6th Framework Programme), but actually - as we know - it does not include palaeoenvironmental research (Mosello et al., 2003). Long-term ecology and conservation biology have been largely considered as two subjects with little relevance to each other (Birks, 2012). How to fill this gap and exchange know-how?

Only recently, palaeoecology and conservation biology give increasing importance to the temporal dimension in developing strategies and policies of conservation in light of current and future biotic, landscape and ecosystem changes (Birks, 2012).

Palaeobotany and plant ecology are highly interrelated areas of theoretical development and, by working in the field of palaeoecology, palynology acts as a bridge between past and modern ecological sciences. These botanical fields have been largely treated as independent disciplines preventing the potentiality of their interrelation. The study of vegetation history and the study of pre-historical and historical human impact are hardly applicable to modern policies of conservation and landscape assessment/planning. The study

of the current global change does not take into consideration the rate of changes observable in geological times. As the modern landscape is the result of a long history of 'nature-culture' dialog, the simple observation of the very recent state of the art is too partial to permit the full understanding of present status and may prevent the correct, or at least most probable forecast of future trends.

Therefore, there is an increasing consciousness of the necessity of reconstructing the long-term trends in ecology for understanding today's vegetation and species richness. This includes palaeoecological methods for studying time scales that go beyond those available through vegetation surveys (Birks, 1996). The integrated methods are also basic for conservation and landscape management. Excellent examples of interdisciplinary approach, including comparisons between present and past vegetation by using the same classification of vegetation and pollen data, come from northern Europe (Hjelle, 2012). We are aware that these studies are more complicated in the Mediterranean complexity due to cultural and biological diversity (Roberts et al., 2011; Mercuri & Sadori, 2013; Torri et al., 2013). Palynology in Italy has a tradition of multiproxy investigations (Magri, 2007), but it was especially developed as cooperation with physical and geological sciences. The cooperation with archaeological and archaeobotanical approaches is rapidly increasing in the last years, while those with modern ecology are still in the initial phase.

The papers included in this volume

This Volume includes sixteen Notes presented at the meeting of the working groups of Palynology, Palaeobotany and Ecology of the Italian Botanical Society held in Modena, 27th -29th May 2013. The meeting provides the opportunity for the participants to exchange ideas, share experiences and recent results from studies on environment, global change, archaeobotany, conservation, cultural landscape and human impact, with special focus on the research carried out by botanists in the different fields.

Hundreds of sites from four countries are discussed in the papers (Fig. 1). Eight papers report detailed studies on one or

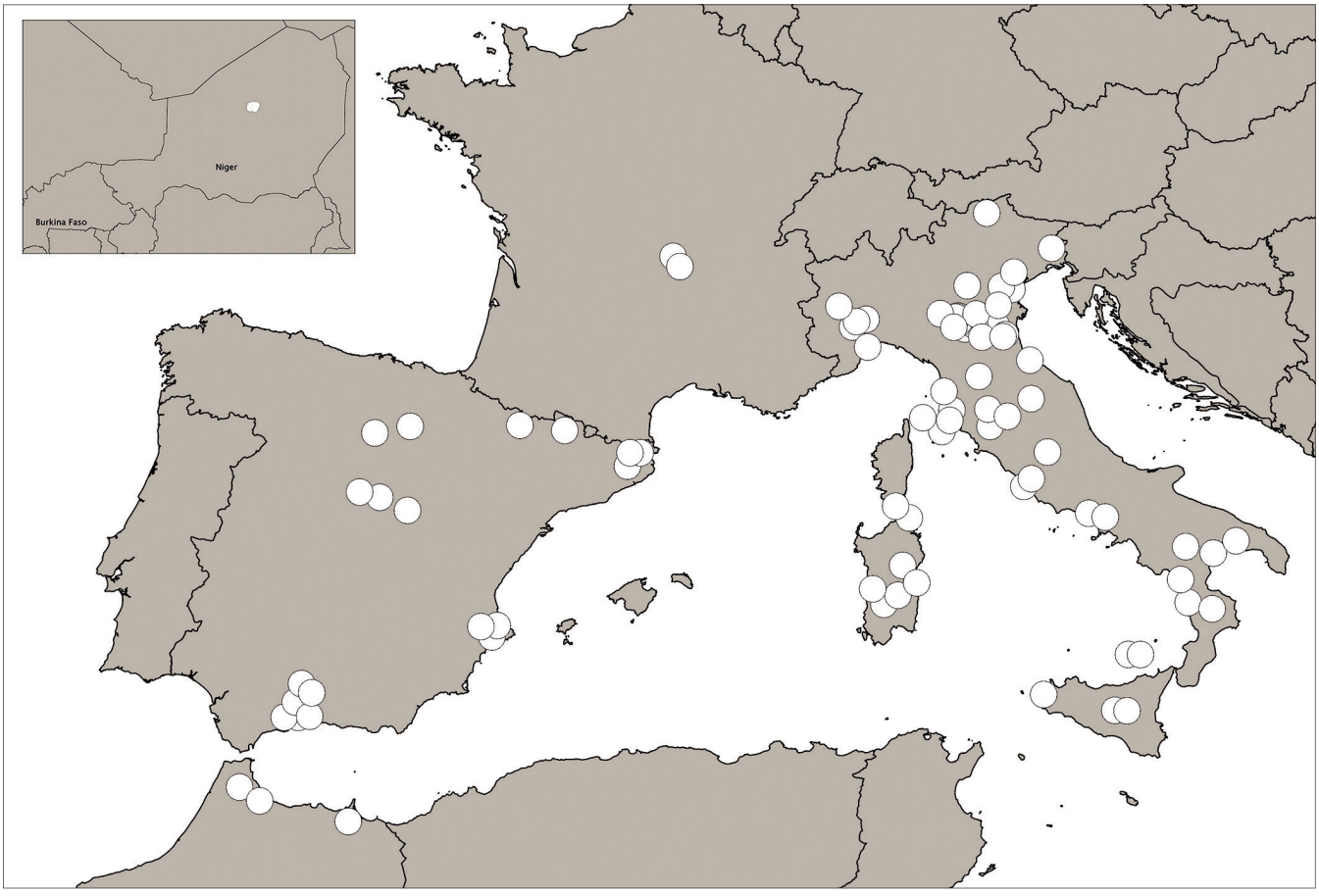

Fig. 1 - Location map of the sites considered in the Notes.

two sites; other eight papers are multi-site researches or even synthesis concerning an area. The geographical focus is on the Mediterranean in a large sense. Almost all researches are carried out in Italy, one paper refers to France (Miras et al., 2013), one to Spain and Morocco (Peña-Chocarro et al., 2013) and one to Niger, in the southern Sahara (Garcea et al., 2013).
Studies on past and present botanical and environmental sets focused from one hand on the ecological relationships between plants and soils, habitats and climate, and from the other hand on the role that humans had, and have, in shaping the plant landscape.

The questions

The papers included in the Notes address a number of questions.
As for methodological approaches, general themes are presented by punctual study cases.

- Which lessons can be learned from multi-proxy palaeoenvironmental investigations, and the integrated palaeo- and ecological approaches (Miras et al., 2013)?
- At what extent the archaeological and environmental evidence from the Sahara desert can complement interpretations on human adaptation to global changes in the Mediterranean basin (Garcea et al., 2013)?
- How much can we go back to the earlier evidence of human impact (Mercuri et al., 2013)? When did the action of humans become detectable and not ambiguous in archaeobotanical records (Buonincontri et al., 2013)?
- At what extension was the landscape transformed by humans or by climate change (Mensing et al., 2013; Ferrari et al., 2013)?
- How did the Romans succeed in managing a port, changing the natural destiny of Mediterranean lands (Giardini et al., 2013)?
- Can archaeobotany be used to integrate archaeology and botany in Hellenistic (Florenzano et al., 2013) and Roman (Rattighieri et al., 2013) sites to understand past transformations and current set of different cultural landscapes?
- Is archaeobotany a key discipline to find recent plant extinctions typical of overexploited wet environments (Rinaldi et al., 2013)?
- Is it possible to find the origin of grapevine cultivation in Italy through the archaeobotanical evidence (Marvelli et al., 2013)?
- Can archaeological and environmental proxies provide a definitive comprehension of the multifaceted and complex nature of farming (Peña-Chocarro et al., 2013)?
- Is palynology a key for understanding present-day vegetation and past plant dynamics of a mountain Mediterranean site (Brugiapaglia et al., 2013)?
- Can pollen morphology be integrated in studies on conservation (Boi et al., 2013; Buldrini et al., 2013)?
- Is the assessment of the level of fragmentation central in the evaluation of landscape resources (Ferrauto et al., 2013)?

The contents

The set of papers give strengthened examples of interdisciplinary studies involving palynology or other botanical fields, and usually integrating the SH-PE-LS ERC domains.
As a model of study on the complexity of dynamics involved in the nature-culture dyad, Garcea et al. report the history of interactions between humans and environment that occurred during the early and mid-Holocene climate oscillations in the Sahara desert (Niger). Thanks to the archaeological coordination of anthropology, litho-stratigraphy, archaeobotany and palynology, data from eight sites show that both climate changes and the geomorphological conformation of the Gobero palaeolake and basin influenced adaptations and subsistence strategies of pre-Pastoral foragers and Pastoral populations.
Also Mensing et al. describe the joint research that anthropologists and historians made with palaeoecologists and climatologists to integrate paleoenvironmental reconstruction and socioeconomic history of the Rieti basin. By comparing the physical and historical records of this area in central Italy, they reconstruct the human impact and climate forcing on ecologic changes since Medieval times. The data suggest that the collapse of local agricultural systems may have occurred during extended periods of cool/wet climate in the Mediterranean.
Miras et al. present a multi-proxy approach research that considers the socio-environmental variables of two complementary sites, a lake and a fen, located in Auvergne-France. Abiotic indicators, such as magnetic susceptibility, and biotic data, such as molecular biomarkers, are used to reconstruct the diachronic history of interactions between human activities and hydro-systems. The long-term models of detrital input and eutrophication correspond to human-induced ecological disturbances.
Peña-Chocarro et al. synthesise the archaeo-biological

studies that were carried out on more than thirty early Neolithic sites located in Iberia and northern Morocco. The earliest examples of domesticated plants are found in the second half of the 6th millennium cal BC, and the diversity of species implies a deep knowledge of plant life cycles, farming systems and agricultural practices in the western Mediterranean region. A quick spread of farming occurred throughout the studied regions while the gathering of wild plants was a common practice especially in Morocco.

Mercuri et al. present a synthesis on anthropogenic indicators that were recurrent in pollen spectra from twenty-six archaeological sites of the Italian peninsula; though peculiar weed and cereal pollen grains were present in off-site cores since the Late Glacial, the evidence of human-induced environments became unquestionable when anthropogenic pollen increased, at the Middle Bronze age, and near the archaeological sites. This was a period of extraordinary innovation. In a synthesis on 112 Italian sites from Mesolithic to Bronze age, Marvelli et al. found that the critical period of grapevine domestication can be placed between Bronze age and Early Iron age. The local use of wild grapevine by indigenous people was, in fact, accompanied to an input of allochtonous vines from Mycenaean and from Hellenic cultures.

Buonincontri et al. give a contribution to the debate on the relationship between the late Holocene climate changes and vegetation history through the charcoal analyses carried out in two archaeological sites of Maremma, in Tuscany; in Etruscan and Roman times, the vegetation was characterized by a degraded evergreen oak forest with sclerophyllous shrubs and low macchia, and then a mixed forest with evergreen and deciduous species covers the area.

Considering the local evidence from the Hellenistic site of Fattoria Fabrizio in Basilicata, however, Florenzano et al. show that the Mediterranean shrubland reflects the degraded landscape that developed in southern Italy starting from a low-forested environment and under continual grazing pressure. The importance of grazing in southern Italy contexts is also enlightened by Brugiapaglia et al. who studied a new core of Lago Trifoglietti; since the Late Glacial, the changes in vegetation, water-depth and annual precipitation were useful to recognize long-term climate variations, and a relatively late and weak human impact was found in this pollen record, probably for the location of the lake in a mountainous belt. After the analysis of ancient maps and aerial photographs of the Garigliano river mouth area, Ferrari et al. drew up a geomorphological map and drilled up several cores for palaeoenvironmental reconstructions including lithology and several biological records. The pollen sequence describes the main vegetational transformations of local wetlands from the Late Bronze age to Middle Ages prevalently due to climate changes, and the expansion of drier environments in the more recent phases as an effect of increasing pasture activities in the area.

In central Italy, Giardini et al. investigate climate changes and human activities using pollen and plant macroremains from the sediment cores of the imperial port of Rome; in a key site for the development of the Roman culture, the plant landscape of the harbour was progressively modified by human pressure, e.g. by planting tamarisks, with increasing clues in the Late antiquity sediments. A very different Roman context emerges from the two small farmhouses of Tuscany studied by Rattighieri et al.; the sites were used seasonally and archaeological/botanical investigations helped to understand the prevalent site function and the complexity of the next agrarian landscape.

Rinaldi et al. report the archaeobotanical study of four sites located in the town of Mutina, giving a further contribution to the understanding of the complexity of the Roman world; this study is a perfect example of the importance of urban environments in times of increasing cultural complexity. The results provided detailed palaeoefloristic lists, and inform about short time changes in cultivation of ornamental plants and food crops, including those that are part of the cultural heritage of the territory, such as vine, walnut and cherry trees.

The biodiversity of Mediterranean landscapes is part of its cultural heritage. This biodiversity can be investigated at different levels, such as that proposed by Boi et al. who presented a study on the micromorphology of pollen grains in the genus *Stachys*, focusing on the variability in pollen traits between populations of the same taxon living in different Tyrrhenian islands. Ferrauto et al. investigate this aspect through the peculiar lens of the agro-ecosystems and the pastures of bees in Sicily. The high state of fragmentation of the nectariferous areas illustrated in maps is caused by the presence of intense urbanization, high transport and infrastructures, agricultural mechanization and the simplification of the agricultural landscape.

Buldrini et al. outlined how also in northern Italy, human activities have caused a progressive and impressive fragmentation of habitats, especially of wetlands. In Emilia Romagna, in fact, the areas suitable for the hydro-hygrophilous species are confined to marginal zones and populations are greatly reduced. An interesting proposal for combining the current protected flora and the pollen morphology of threatened species is presented. The possibility to discover the presence of some species by its pollen type, when it is well identifiable, can help to detect sites for their reintroduction, even in the absence of other direct documentation, and according to the ecological requirements of the species.

The palaeoenvironmental sciences help to investigate past human activities and their impact on the environment whose effects are visible even today. The joint palaeoecological and ecological research is empowered by a great potentiality to understand the vocation of territories, and to outline the

future planning guidelines for the protection and environmental management to reach sustainability.

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