

# What is natural: the role of palaeoenvironmental research in reconstructing the history of continental ecosystems

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**Summary:** *Here I argue that palaeoenvironmental research is one of the few tools available to decipher the complex evolution of continental ecosystems and the role played by humans. For this purpose, there is a wealth of archives and proxies that can be integrated to obtain information on the history of ecosystems. Some examples from Spain are given, as the reconstruction of atmospheric metal pollution -due to mining and metallurgy since prehistory- and its coupling to changes in forest cover, and soil degradation (erosion and acidification). But also on induced changes that shifted some specific habitats into a state that is of present priority protection. From this long-term perspective the questions of what and when is natural are less relevant than understanding the complex coupling between environment and humans.*

**Key words:** *environmental change, archives, multi-proxy research, human-environment interactions.*

There seems to be a consensus on the fact that we are facing a situation of global environmental change, in which human transformations may play a critical role. For some, the degree of human alteration of the “natural” biogeochemical cycles is so large that the term “*Anthropocene*” has been proposed to indicate that in the last few centuries we entered a human-dominated, geological epoch (Crutzen and Stoermer, 2000). The awareness of such a situation has also led to increased concern in developing mitigation and conservation measures/strategies. The latter have seldom incorporated time perspectives longer than a few decades, or a century at most. But it is well known that changes in continental ecosystems functioning occur at different time scales, and a long-term perspective is needed for a proper understanding of the timing and drivers of the changes. Palaeoenvironmental research is one of the few tools that can provide a valuable long-term perspective on the dynamics of ecological systems (Willis and Birks, 2006).

There is a wealth of archives (i.e. marine sediments, glacier ice and snow, lake sediments, colluvial soils, peat) and proxies (i.e. biotic: fossil pollen, non-pollen palynomorphs, seeds, tree rings, charcoal, animal remains, etc.; and abiotic: chemical elements, isotopic composition, organic compounds, etc.) that enable the reconstruction of environmental changes. In regard to human transformations, a major aim is to identify and separate the so called “natural” and “anthropogenic” signals, thus to determine what is natural. But this is intimately linked to the question: when is natural? That is to say, to determine the earliest evidence of human transformation as a significant driver of biogeochemical cycles. One such example is the reconstruction of atmospheric metal pollution initially linked to mining and metallurgy, and later to fossil fuel combustion (coal and petrol), waste incineration, etc. For Spain, for example, the use of metal concentrations, enrichment factors and isotopic composition (mainly for lead)

resulted in detailed chronologies for the last few centuries (Martínez Cortizas *et al.*, 2011) and also for the last 8000 years (Kylander *et al.*, 2005). Although for Pb the start of significant anthropogenic contributions started 3000 years ago (Kylander *et al.*, 2005), recent investigations based on isotopic composition have pushed back the first evidence of metal contamination in N Spain to the earliest metallurgy, almost 5000 years ago. Comparisons between records of different heavy metals also revealed phases of polymetallic contamination (like the Roman period or the Industrial Revolution) and periods when only one or a few metals dominated (as for example Ni in the Bronze age). The records from distant areas like Galicia (references mentioned above) and Catalonia (Camarero *et al.*, 1998, Serrano *et al.*, 2011) also showed the presence of general as well as local patterns –linked to the history of particular areas.

Since metal pollution is an indication of mining/metallurgy, and these reflect economic activities demanding other resources, it was not surprising to find that the combination of geochemical and palynological records for the same archives (i.e. peat cores) revealed that pollution was synchronous with the fate of the forests (Martínez Cortizas *et al.*, 2005), forest cover decreasing when pollution increased.

Human activities were also involved in landscape changes at longer time scales. In N Spain, for example, the interaction between human activities and the environment were expressed as modifications of the vegetation cover, the elimination of the soil resource (by erosion) in many places and its concentration (by re-sedimentation) in more localized, control-demanding areas, as well as the progressive acidification of continental ecosystems (Fig. 1). But in some specific situations, human induced changes also produced shifts in the structure of former habitats that lead to a present state labeled as “priority protection” in the European

legislation (as the Natura 2000 network). A good example of this has been recently described by López-Merino *et al.* (2011). They found that the palaeoecological history of La Molina mire demonstrates that human intervention (by inundation of the former fen in Roman times) promoted a rapid evolution to an ombrotrophic bog, declared at present as Site of Community Importance.

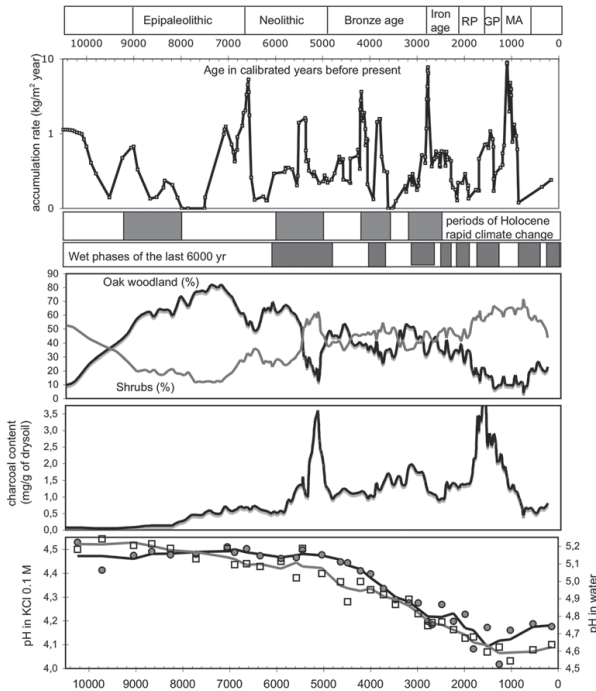


FIGURE 1. Holocene changes in soil erosion/accumulation rates (log scale), vegetation change, charcoal content and soil reaction (pH) in Campo Lameiro (Pontevedra, NW Spain). Taken from Martínez Cortizas *et al.* (2009).

In conclusion, in Spain and many other parts of Europe the long and intricate history of human transformations of the environment has resulted in the conformation of present cultural landscapes. Palaeoenvironmental research can provide information on pre-impact states of ecosystems, trajectories of prehistoric and recent changes, and complex system behaviour (Dearing *et al.*, 2006), which is critical for the understanding of our past, for ecological modeling and to develop proper conservation strategies. As the time perspective is enlarged, the questions of what and when natural fade away is, and human-environment interactions appear as the result of coupled complex systems.

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