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Landscape Systems and Human Land-Use Interactions in Mediterranean Highlands and Littoral Plains during the Late Holocene: Integrated Analysis from the InterAmbAr Project (North-Eastern Catalonia)

Landscape evolution; land-use; paleoenvironment; archaeology; catchment-based interactions; Mediterranean environments; Late Holocene.

Introduction

The main goal of the InterAmbAr research project¹ is to analyze the relationships between landscape systems and human land-use strategies on mountains and littoral plains from a long-term perspective. The study adopts a high resolution analysis of small-scale study areas located in the Mediterranean region of north-eastern Catalonia. The study areas are distributed along an altitudinal transect from the high mountain (above 2000m a.s.l.) to the littoral plain of Empordà (Fig. 1).

High resolution interdisciplinary research has been carried out from 2010, based on the integration of palaeoenvironmental and archaeological data. The micro-scale approach is used to understand human-environmental relationships. It allows better understanding of the local-regional nature of environmental changes and the synergies between catchment-based systems, hydro-sedimentary regimes, human mobility, land-uses, human environments, demography, etc.

Materials and Methods

In each study area, paleoenvironmental, archaeological and historical data have been cross-checked. Multiproxy paleoenvironmental analyses including sedimentology, geochemistry, pollen, NPP (non-pollen palynomorphs), charcoal, diatoms and crustaceans from lacustrine or peat records have been obtained. These palaeoenvironmental data have been integrated with results obtained through geomorphology, archaeomorphological research, archaeological field survey, excavations, ¹⁴C dating, historical research, remote sensing and GIS analyses. GIS allows data correlation and integration in a multilayered and multiscale environment where diachronic analysis can be performed.²

1 InterAmbAr “Integración de datos paleoAmbientales y Arqueológicos para la interpretación de las interacciones climático-socio-ambientales en una cuenca del NE peninsular durante el Holoceno” is a R+D project, funded by the Spanish Ministry (CGL2009-12676-C02-02).

2 Orengo and Palet 2010.

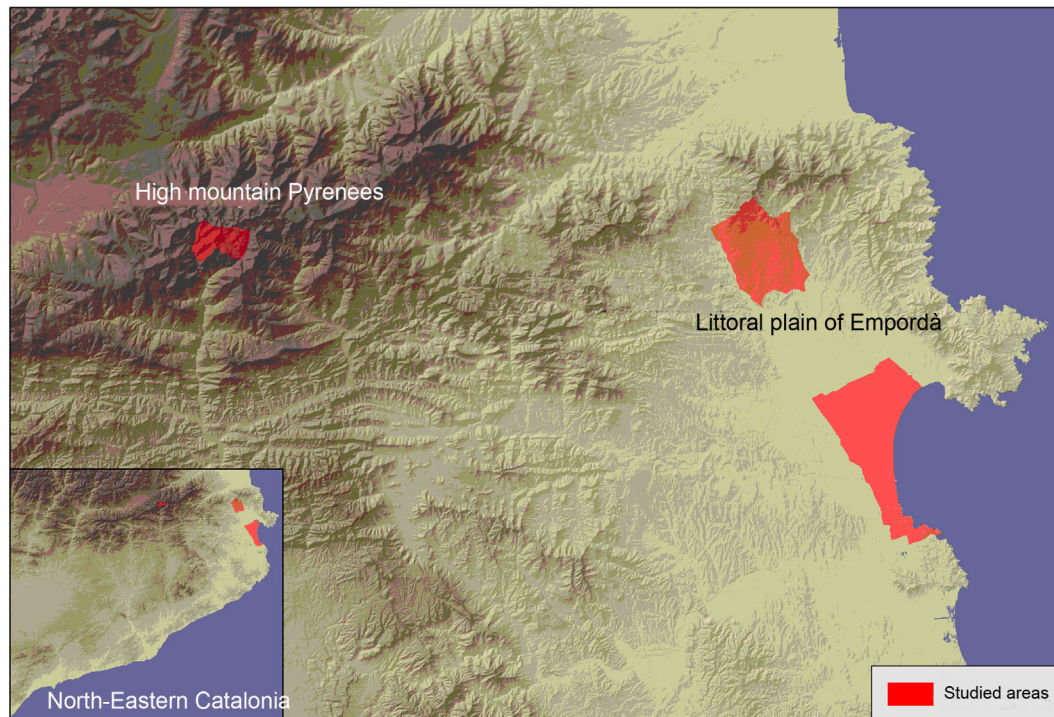


Fig. 1 | Location of studied areas.

A sedimentary record of 6,5m depth has been obtained in the Castelló lagoon, located in the littoral plain of Empordà. In the high mountain Pyrenees five peat records of between 130 and 50cm in thickness, have been studied at the head of Ter River. About 30 radiocarbon dates provided the chronological framework to compare the high mountain and littoral paleoenvironmental sequences. These ^{14}C dates were calibrated using Calib 6.0 program.

The data obtained allowed us to characterize landscape shaping and evolution in each study area, particularly between the Iron Age (6th–2nd centuries BC) and recent times.

Preliminary Results

The paleoenvironmental record of the Empordà plain provides evidence of successive environmental changes during the last 5000 years. Between 2850 and 2700 cal BC, the plain was characterized by a wooded oak landscape bordering a brackish lagoon. From this period until Roman times, the brackish lagoon was connected with the sea and a marine environment prevailed in this part of the plain. During this period, the inland sector of the plain records the first clearances and farming activities, coinciding with the development of Iberian culture (6th–2nd centuries BC) and the foundation of the Greek colony of *Emporion*, dated at 6th–5th centuries BC. The Iberian culture in this area is characterized by an especially high territorial organization and intensive agriculture, based on cereal and vineyard crops, and grazing.³

The Roman conquest and the occupation of this territory from the 2nd–1st century BC involved a new process of landscape shaping. Settlement distribution from this period shows intensive rural occupation of the plain.⁴ In addition, archaeomorphological

3 Plana and Martin 2005; Picazo et al. 2005; Puig and Martin 2006.

4 Palet and Gurt 1998; Nolla, Palahí, and Vivó 2010, 75–93.

research of landscape morphology reveals centuriated grids with different modules and orientations surrounding the Roman city of *Emporiae*. These structures spread through fluvial terrasses and inland deltaic plains. On the other hand, from Roman to Early Medieval times (10th century AD), the deciduous woodlands were progressively deforested and farming and mining activities expanded in the plain. During Early Imperial times environmental data attest that the marine water conditions of the lagoon changed to a brackish environment suggesting the development of sandy bars.

During Early Medieval times (10th–13th AD), large deforestations related to the expansion of farming and mining took place in this littoral plain. At the same time, the sandy bars progressively closed the lagoon. A strong territorial organization is also attested by historical data during this period, as a consequence of the foundation of medieval villages, churches and castles during Christian colonization of the area.⁵ From the 13th century AD, freshwater conditions in the lagoon prevailed. Later, the lagoon was progressively filled by sediments, as a consequence of the fluvial thalweg management and drainage works, as has been documented in written sources.⁶ At this time, woodlands recovered while littoral meadow pastures (called “closes” in the area) expanded. This littoral plain was extensively used as pastureland during the Modern Age, mainly for transhumant livestock.

The intercomparison of peat records in high mountain areas suggests that peat formation could be related to human land management, probably deforestation or mining activities, which affected the hydrological system. Three main phases of peat formation have been reported during the last 2000 years: in Roman times, 6th–7th centuries AD and 12th century AD.

During Roman times, altitudinal grasslands developed above 2000m a.s.l. as a consequence of pine and fir woodlands deforestation. Meanwhile, geochemical data indicate that Cu and Pb exploitation was the main human activity. In addition, archaeological survey and excavation documented an Early Imperial times hut located above 2100m a.s.l. This structure is related to an ancient East-West road axis, probably associated with the reported mining activities.

A new deforestation process occurred during the 6th and 7th centuries AD coeval with the grazing expansion. During the 8th century AD, a mining phase could be related to the exploitation of arsenopyrite in the area. Furthermore, archaeological evidence shows that Early Medieval times (9th–11th AD) are characterized by the expansion of grazing activities as is attested by pollen data and the presence of numerous medieval huts and enclosures.

Between 1200 and 1600 cal AD, a new deforestation phase resulted from the large grazing use of high altitude pastures and intensive mining and metallurgy, an activity reported by written sources (Fig. 2). This large grazing activity probably was the result of the establishment of transhumance linking these summer mountain pastures with littoral meadows. Later on, from the 18th century, mining activities were focused on Fe and Pb. This activity coexisted with the pastoral use of the area until the 19th century when livestock declined and forest recovered in a context of mountain depopulation.

Conclusions

In both sectors, the new multiproxy and archaeological data show the variability of natural resources exploited in different periods. This variability seems to be related to dynamics in the spatial organization.

5 Bolos and Hurtado 1998; Bolos and Hurtado 1999.

6 Marques 1993.



Fig. 2 | High altitude pastures in Puigmal massif (2910m) (Nuria valley, Eastern Pyrenees).

The Roman landscape occupation probably involved a complementary exploitation of natural resources in north-eastern Catalonia. A certain specialization of resources by geographic areas is attested, focused on agriculture and livestock in the littoral plain and mining in high mountain areas. Later, during Late Antiquity (6th–7th AD), mountain and littoral resource exploitation diversified in the context of a more self-sufficient economy. In this sense, the development of metallurgical activities is now documented in the littoral plain, while livestock expanded in the high mountain Pyrenees.

In Medieval and Modern times, new complementarities and interrelations were established between mountains and plains. Transhumant livestock connected the entire catchment area. In addition, metal production was based on the mineral extraction in the high mountains and metallurgy in lower areas which contributed to these new complementarities between areas.

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