"The natural environment is the evolutionary cradle of the decision-making apparatus of humans; hence, one needs to wait and see until a certain level of the underlying emotional system stimulates its capacity to adapt to and survive environmental change confronting humanity today" – Dr. Juan Puigdefábregas (2015?)

Lecture 28 - Keynote

Origin and development of subalpine landscapes in the central spanish pyrenees

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1. The scientific framework

Almost forty years ago, Juan Puigdefábregas and the first author of this paper started the geoecological study of the subalpine belt in the Central Spanish Pyrenees (Fig. 1). Around the same time, while studying the glaciolacustrine sequence of the Tramacastilla Lake (Gállego Valley, 1675 m a.s.l.), Montserrat (1991) discovered fire events at 3500-4000 yr BP and at 900-1000 yr BP in the subalpine belt. However, the Middle Age fires were enormously important in both extent and geoecological effects, causing (i) a permanent transformation of plant cover, with the replacement of most forests and the expansion of grasslands, and (ii) an increase in overland flow triggering intense erosion. This represented rapid transformation of the subalpine landscape between about 1500 to 2200 m a.s.l., redistribution of soil, and the development of parallel rills, gullies, solifluction lobes, ravine headwaters, gelifluction terracettes and shallow landslides. Several papers were focused on the study of landslides and the factors that explained their occurrence (Puigdefábregas and García-Ruiz, 1983; García-Ruiz and Puigdefábregas, 1984; Puigdefábregas and García-Ruiz, 1984), and the distribution of geomorphic processes (García-Ruiz and Puigdefábregas, 1982). Del Barrio and Puigdefábregas (1987) emphasized the role of topographic factors in the spatial distribution of mass movements. Recently, new contributions have set bounds to the moments of deforestation through dates obtained from detailed analyses of high-altitude lacustrine sediments (Pérez-Sanz et al., 2013; Leunda et al., 2017), charcoal in soils (González-Sampériz et al., 2017, 2019), and the presence of humans in the subalpine belt during the late Holocene (Clemente et al., 2014; Laborda et al., 2017). Juan Puigdefábregas participated in a recent review on shallow landslide activity (García-Ruiz et al., 2010).

2. What do we know about landscape evolution in the subalpine belt?

Several studies have confirmed the presence of humans in the subalpine belt in summer since the Neolithic. Palynological records from lacustrine sediments do not record relevant changes in the proportion of arboreal pollen (AP) (González-Sampériz et al., 2017). Most likely, they were shepherds with small sheep flocks benefitting from the distinct phenological activation in the mountain belts. Long transhumant movements should be ruled out given the fragmentation of the territory before the Roman Period (González-Sampériz et al., 2019) and the inexistence of major markets for meat and wool. Shepherds would practice transterminant movement from the villages located in the valley bottoms. Consequently, the opening of the forests would have been extremely limited to small areas, maybe related to the necessity of visualizing the presence of bears or wolves.

The occurrence of fires in the subalpine belt has been confirmed with the study of lacustrine sediments. Thus, both the Basa de la Mora and Marboré lacustrine sequences (1900 and 2600 m a.s.l.) show charcoal peaks at approximately 4000 cal yr BP (Leunda et al., in press), and the Tramacastilla Lake sequence shows the occurrence of fires between 3500-4000 yr BP, although changes in plant cover were short and negligible (Montserrat, 1992). Many other charcoal records could be related to intentional fires to enlarge the grassland areas, although they could also have had a natural origin (González-Sampériz et al., 2019). Archaeological records also reveal the occasional presence of shepherds above 1500 m. This is the case of prehistoric rocky shelters in the Pardina Valley, Ordesa and Monte Perdido National Park, at approximately 1900 m a.s.l., since 4600 cal yr BP (Laborda et al., 2017). The frequent presence of megalithic monuments (dolmens and cromlechs) is the best evidence of prehistoric pastoral activity in the high-mountain Pyrenees. They are located near trails traditionally used by shepherds or in highly accessible, relatively flat areas, disappearing in remote areas, thus suggesting that summer grasslands were originally small with easy access for grazing.

Changes in the subalpine plant cover since 900 AD are more evident, and particularly, since 1300 AD (González-Sampériz et al., 2017), with a general and consistent decline in the proportion of arboreal pollen and the enhancement of erosion due to deforestation and the altitudinal decline of both the timberline and solifluction limits. Forest wasting was related to the occurrence of transhumance following the Reconquest of the Central Ebro Depression by the emerging Christian kingdoms, and the enlargement of international wool markets, as well as mining activity in some areas.

Erosion continued affecting the Pyrenean subalpine belt during Modern and Contemporary Ages. During the second half of the 20th century, the crisis of transhumance systems and the declining number of ewes has resulted in partial forest recovery, which is progressively ascending toward the divides.

3. What do we need to know about the subalpine belt?

In spite of the advances in the study of geoecological aspects of the subalpine belt, some problems are still pending. For instance, we need to know the areas deforested in prehistoric times, particularly in relation to the location of megalithic monuments. The development of extent hillslopes affected by intense rilling and gullying also remains obscure. The deep incision of rills and gullies suggests that they would have needed more time to evolve so deep (Fig. 1). Were these areas deforested early despite their inappropriate location? The actual evolution of the timberline following the decline of transhumance is also a key geoecological issue in forecasting the expansion of the forest and its hydrological consequences.

4. Conclusion

The first anthropic impacts on the subalpine belt in the Central Pyrenees were in the Neolithic, when small, well-accessible areas were burnt to favour the transterminant sheep flocks in summer. Nevertheless, the development of transhumance and the presence of large sheep flocks since Medieval times was the main reason for the almost general deforestation that resulted in increasing landscape heterogeneity and intense erosion.

Lecture 29 - Oral

Biodiversity in Andalusian olive orchards: assessing the effect of agricultural management and landscape simplification.

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Introduction

Olive tree plantations are the cropland with the strongest economic impact in Europe and have the highest potential for biodiversity maintenance in the Mediterranean Basin. Unlike annual croplands, the stability and higher structural complexity of arboreal farmlands makes olive plantations especially favourable for establishing and recovering biodiversity. There is evidence that agricultural practices have considerably pauperized biodiversity in olive croplands. Nevertheless, both knowledge of the biodiversity harboured in olive plantations and our understanding of the consequences of agricultural management in terms of loss of biodiversity and ecosystem services in this culture is very limited. Such knowledge is important given the extension of the olive groves in various types of habitats and the recent trend of replacing olive groves with a sparse plantation frame by super-intensive olive plantations. This trend is particularly worrying in the semiarid southeast of the Iberian Peninsula, where large extensions of natural vegetation are being replaced by super-intensive olive plantations.

As part of a long-term project on biodiversity and ecosystem service recovery in olive plantations (OLIVARES VIVOS, LIFE14 NAT/ES/001094, http://olivaresvivos.com/es/home/ and Spanish Ministry of Economy and Competitiveness CGL2015-68963-C2-1-R Projects), we present here the first regional evaluation of biodiversity of olive tree landscapes in Andalusia (southern Spain) and of the factors affecting it. Our study is framed in recent conceptual advances on the modulating effects of landscape complexity on biodiversity and ecosystem service enhancement through extensification practices: the "landscape moderation of biodiversity pattern and function" (LMB, Tscharntke et al. 2012). These hypotheses seek to find out the extent to which increased landscape complexity and agricultural extensification would enhance biodiversity, ecological functions and ecosystem services in human-modified landscapes. They also state how landscape complexity moderates the effectiveness of agri-environment schemes (AES) for recovery of biodiversity and ecosystem services. Here we report on the results of plant and animal biodiversity in relation to landscape complexity and extensification-intensification practices (herbaceous cover management).

Methods

Twenty localities were selected from the largest areas of olive groves in Andalusia with a wide gradient of landscape complexity. Young, modern hedge-like plantations were discarded. Two olive farms were chosen in each locality (total of 40 farms): (1) one farm with intensive weed cover management (use of pre-emergence and/or post-emergence herbicides and/or recurrent plowing for cover elimination); and (2) a farm with extensive weed management, implying their maintenance during most of the year. Farms were: (1) small (< 25 ha, most frequent < 10 has), and (2) large (> 50 ha, most frequent > 100 ha).