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# Pastoral activities and soil erosion processes: calibration and confrontation of organic and minerogenic markers from Pyrenean archives (Orry de Théo and Troumouse peat bogs).

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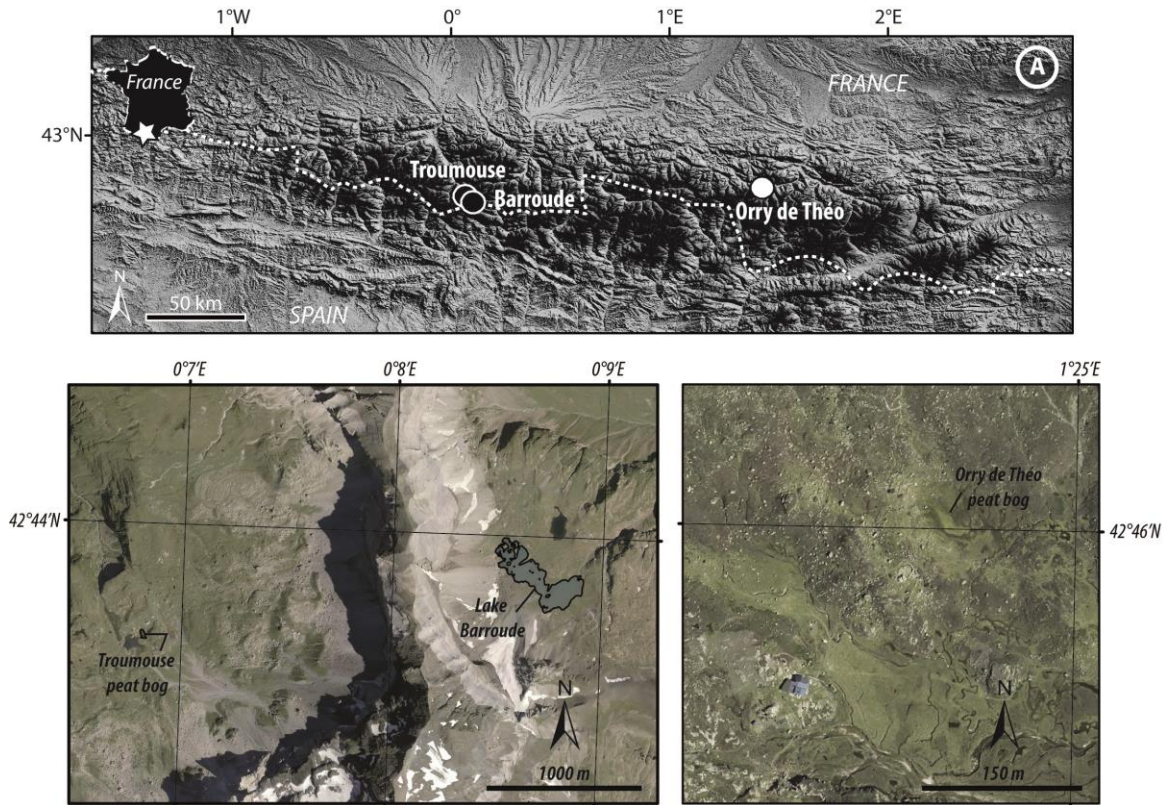
For more accurate prediction of the consequences of current global warming, it is important to disentangle the past impact on ecosystems of climate variability and human activities, in both the long and short term (Dearing and Jones, 2003). The mechanical erosion of continental surfaces mainly results from climate forcing (precipitation/runoff, vegetation changes...), but may be initiated, amplified and accelerated by anthropization (deforestation, plowing, grazing...). High altitude ecosystems are sensitive and therefore constitute relevant targets in which soil-erosion quantification can be used both to reconstruct climate changes (Simonneau et al., 2014) and to document the local consequences of human activities. In addition, such human-induced soil erosion indirectly reflects socio-ecological trajectories over time.

For thousands of years, grazing has affected Pyrenean areas and is considered to be the main biotic factor creating pressure on ecosystem structure and the dynamics of mountain pastures (Galop et al., 2004; Mazier et al., 2009). Indeed, recent studies suggest that pastoral activities increase soil erosion rates (Adler and Morales, 1999; Ayala and French, 2005), especially in mountainous regions (Hall et al., 1999). Yet, though such interaction between grazing and erosion can be hypothesized, the causal relationship has been neither established nor quantified (Thormes, 2007). Such proof, however, is essential if public policy in the field of land-use management is to be credible.

With this in mind, the on-going French research program "pastoralisM versus erosiOn: expLoration of molECULAR biomarkers for tracking human/Environment interactions" (MOLECULE, Labex DRIIHM – CNRS INEE) clearly aims to reconstruct the impact of grazing on soil erosion during the Late Holocene. In well-dated peat bog archives (Orry de Théo and Troumouse, Pyrenees), soil erosion (from organic and minerogenic markers) is studied alongside pastoralism (from coprophilous fungi and fecal molecular biomarkers: bile acids and sterols).

The peat bog archive from Orry de Théo (Eastern Pyrenees, fig. 1) over the last two centuries is used to calibrate fecal tracers. Quantitative evolution of pastoralism tracers is compared to size and composition of livestock populations as described in detail in local archives (Galop et al., 2011). The markers of pastoralism can thus be quantitatively related to proportions of the livestock (i.e. ovine versus bovine). The authors then explore any quantitative relationship between the number of tracers and the size of the livestock. Finally, it is hoped that crucial information will emerge concerning any latency or time lag in the recording of molecular tracers due to varying residence times in soils or to varying transportation times from source to the archive.

The Troumouse peat bog (Central Pyrenees, fig. 1) covers the last 6000 years and is located only a few kilometers from Lake Barroude (fig. 1), where climate-induced erosion processes over the Holocene have been quantified. At Troumouse, soil erosion fluxes reveal six major detrital phases dated from 3910-3855, 3445-3225, 2780-2740, 2655-2525, 1700-1510 and 735-515 cal BP. Anthropogenic indicators suggest that human activities in the vicinity of the bog date from 5000 cal BP. Moreover, Louis Ramond de Carbonnières described intensive historical land-use management for grazing activities in the area but specified neither the type nor the number of animals involved in these practices. By applying our calibration to this new sequence and comparing local soil erosion fluxes, potentially influenced by grazing, to the local climate signal, the authors hope to demonstrate and quantify pastoralism and to establish whether or not it is a true agent of erosion.



**Fig. 1.** Localisation of the studied sites in the French Pyrenees.

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