



## **Positive effects of millennial grazing on soils in the western French Pyrenees**

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Many hillslopes of the western French Pyrenees have been grazed for thousands of years following the introduction of sheep about 7500 years ago, yet little is known about the long-term effects of pastoral activities on soil properties and pedogenic processes in this humid-temperate mountain range. In the 13 square kilometer Basque commune of Larrau we compare the status of soils under old pastures to those under old-growth forests at elevations ranging from 1000 to 1600 masl. Four separate tracts of side-by-side pairs of pasture and old-growth forest were sampled to discriminate differences in physical and chemical soil properties. Five paired soil profile samples were taken from each vegetation type on each tract so that all factors of soil formation, except vegetation type, were similar for each pair. Animal trails were excluded from sampling. We also developed radiocarbon chronologies of sedimentation rates from colluvial deposits at four other pasture sites to evaluate possible differences in the magnitude of soil erosion and sedimentation before and after conversion to pastures during the Holocene.

Results indicate pastured A horizons are about three times as thick as forested soils, have significantly lower soil bulk densities, and much finer and stronger structural development of soil aggregates. These traits favor much greater infiltration and water holding capacities of the pastured soils. Thus, very significant pedogenic reorganization occurred in the pastures that can be viewed as improvements in soil quality. Inorganic nutrients in the pastured soils have significantly lower concentrations than in forested soils, except that amorphous silica is more abundant within pastured soils presumably due to greater phytolith production. The amount of nutrient depletion does not appear to be a limiting factor for grass growth and biomass production.

Sedimentation chronologies indicate that erosion and sedimentation rates slightly increased following the earliest pronounced occurrence of macroscopic charcoal in the colluvial stratigraphic sections. We interpret the charcoal record to indicate that fire was used to improve grazing, and over time fire and grazing resulted in forest to pasture conversion. Although sedimentation rates increase after conversion to pasture, the rates remain rather low (<1mm/yr) and they are similar to rates measured in forested environments of other humid mid-latitude regions. Thus, stereotypical erosion and land degradation from grazing is not apparent in the study region.

Our results indicate that the grazed landscape of Larrau represents sustainable pastoral land use over millennial timescales. Furthermore, our data provide insight about altered pathways of pedogenesis caused by human use and manipulation of the landscape.